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THE BERBERS OF EASTERN ALGERIA

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In the text names are given in the French form throughout, sometimes with the P.C.G.N. transliteration of Arabic and Berber names in brackets. On the map the G.S.G.S. practice has been followed.

THE Aurès mountains of eastern Algeria constitute one of the most clearly defined cultural regions in the whole of North Africa. No part of Barbary possesses a more vigorous and distinctive personality, or reveals such astonishing contrasts.

As African mountains go, the lozenge-shaped massif of the Aurès is neither spectacular in size nor in elevation; only in the extreme north does it rise above 7000 feet and nowhere is it more than 100 miles in length or breadth. In their western half these fold mountains are aligned in a north east–south west direction and describe long rectilinear ranges. Towards the east the alignment is more latitudinal. The main axis of the system, Djebel Azreg, is an anticline of lower Cretaceous age with a Jurassic core which forms the northern rampart known as Chélia (Shelya), the highest peak of the Aurès. Everywhere the massif is deeply ravined by wads. Geographically the most important of these are the oued el Abiod and the oued Abdi engulfed between the Djebel Mahmel in the west and Ahmar Khaddou in the east. These multi-coloured calcareous formations are everywhere imposing, and when flushed by the rays of the setting sun they present a spectacle of rare beauty. The abrupt southern termination of the Aurès mountains is due to severe faulting.[1]

For a massif of such modest dimensions, intermontane communication is surprisingly difficult and the isolation of the country, historically very acute, is still serious. Even to-day there is no good road through the Aurès. The track that styles itself *Route Nationale* has a high car-mortality rate. Although

[1] On the structure of the Aurès, see A. Bernard and E. Ficheur, "Les Regions Naturelles de l'Algérie," in *Annales de Géographie*, vol. xi, 1902.

the Roman legions penetrated right into the heart of the country,[1] they did not succeed in building a single metalled highway: a tribute, partly at any rate, to the rough grain of the topography. Here in the heart of a French colony which is generously equipped on the whole with useful roads and railways, we can still observe the life of a people without communication other than the veriest tracks, and without motive power other than the feet of draught animals; for apart from a very limited motorbus service between Batna and Arris (the administrative centre) and Batna and Menâa (one of the largest villages), the only satisfactory method of travel is either by camel or mule. These animals have a longer expectation of life than most cars, and they may even prove faster. Whereas you may have to go 50 miles to get from one important village to another by car, the mule track over the mountains may be less than five.[2]

In such a difficult terrain it is not surprising that the outside world has remained woefully ignorant of the Aurasian people. For several centuries after the time of the Romans nobody appears to have visited them at all; admittedly the Arabs prevailed upon them to accept the Muhammadan faith, but they never settled among them, and, in common with the Romans, Vandals, and Byzantines before them, they were unable to impose their mode of life upon them. More recently the French have carried their authority into this territory, but the number of French people residing in the Aurès is very small.[3] Accordingly, the Aurasian population has undergone little, if any, ethnic change in modern times. As in the case of Kabylia, the only other conspicuous area of Berber culture in Algeria, the Aurès mountains have served as an asylum of primitive racial stocks, whose precise origin is unknown and probably unknowable.[4] It is thought by some that they represent the end-product of a slow amalgamation of different Semitic peoples, such as the Getulians and Lybians. Masqueray regards them as a by-product of the Roman occupation (many Berbers pride themselves on their Roman origin); Ferand believes that some of the Chaouïa (Shawiya) tribes (the name by which they are most generally called) are a mixture of autochthonous and Jewish-Christian refugees who fled to the mountains at the time of the Arab invasion.[5] Certainly there is little ethnic uniformity among the Chaouïa tribes.

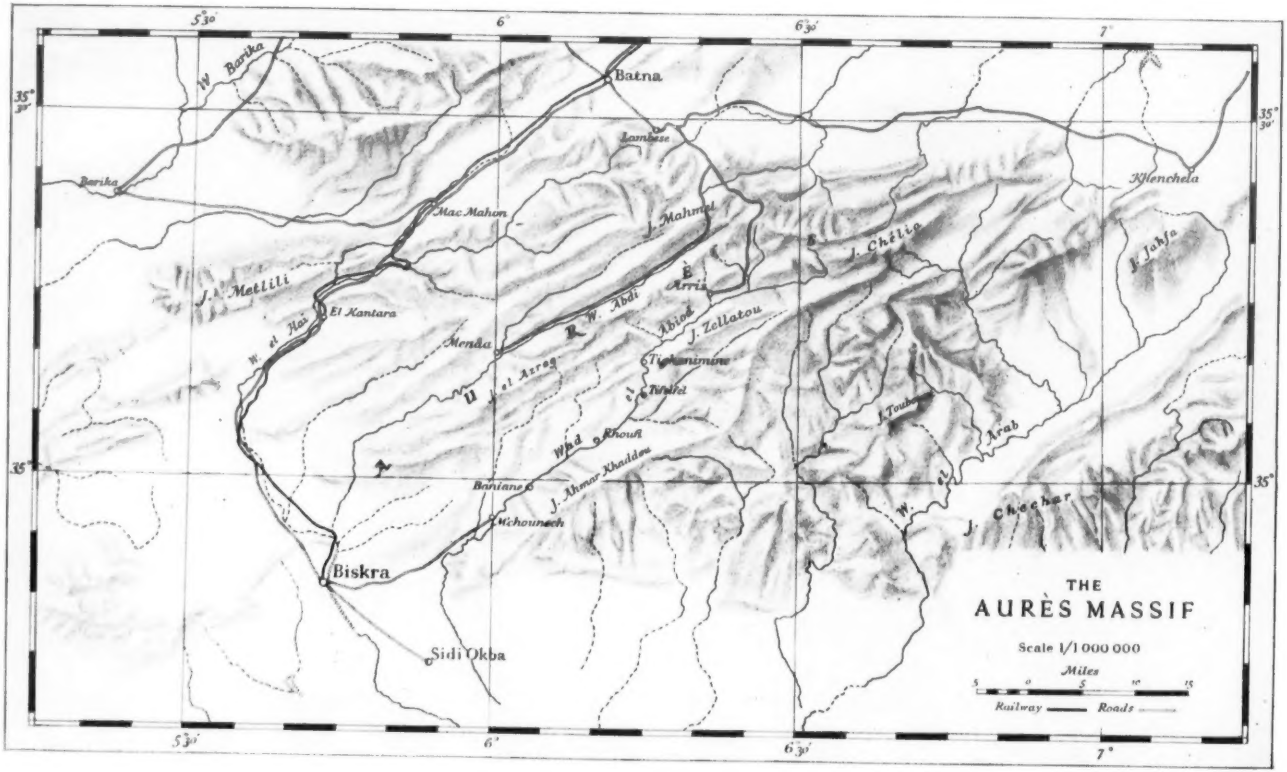
[1] Rock inscriptions relating to the exploits of the legions are quite common; so, too, are evidences of Roman cultural influence. In the gorge of el Abiod (near Tighanimine) there can still be seen a section of an irrigation canal (séguia) built by the Romans, and, until recently, one of the Aurasian tribes, the Beni Ferah, used a block-and-tackle device very similar to that described by M. Cato in his treatise 'On Agriculture.'

[2] Signposts in the Aurès commonly give the distance in hours—for mules.

[3] The total number of French citizens (including naturalized natives) in the Aurès Commune at the time of the 1936 census was only one hundred and eighty one; almost all of these were engaged in government work: administration, forestry, police. The number of French "colonists" was negligible.

[4] The very derivation of the "Berber" is uncertain. It may have come from *βαρβαροι*, or from the Barabara and Beraberata tribes spoken of in Egyptian inscriptions of the seventeenth and thirteenth centuries B.C. The Kabyles and Chaouïas call themselves "Imaziren" and their language "Tamazirt."

[5] Among the lines of evidence supporting this contention is the fact that the Chaouïas possess certain Judaistic and even Christian customs, *e.g.* they use the Julian calendar and observe a kind of Christmas feast which they celebrate with the help of a "tree" and appropriate decorations.


5° 30'
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W. Barika
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J. Chélia
J. Jahfa
J. Metlili
El Kantara
W. el Kaï
Menâa
R. W. Abdi
Arris
Abiod
J. Zellatou
W. el Arreg
Tighanimine
Timgad
J. Toukbal
Arab
Wad Rhoui
J. Ahmar Khaddou
Bantiane
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J. Chegher
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THE
AURÈS MASSIF
Scale 1/1 000 000
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Railway
Roads

1. Gorge of the oued el Abiod

2. Cliff village with guelâa, Haïza, oued el Abiod

Some are lightly pigmented, and of tall stature, strangely reminiscent of more northern types.[1] Others are of a type akin to the Corsican and South Italian; yet others are of the broad-shouldered, slender-hipped type so widely spread over the basin of the Nile.

In religion the Chaouïas follow Mohammed, without deep piety, but with a fanaticism which makes them the ready prey of the marabouts (*i.e.* the priestly caste from which the sheïks are recruited: all claim descent from the Prophet). Alongside the official religion they practise a second—a survival in composite form of animism, fetishism, zoolatry, and other pagan cults. Sacred spots, "high places," and groves abound. Certain rocks have miraculous properties: to these come men and women about to be married, and the women come again if they have been unsuccessful in giving birth to a son. In some areas, instead of rocks, trees, or even piles of dead wood are similarly invested; and no matter how hard up for fuel the Berber is, he would rather die than take a piece from such a heap, for perchance there lies buried beneath a marabout whose power for good and ill no native dares question.

Culturally, linguistically, and racially the Chaouïas are closely related to the Kabyles, with whom they share somewhat similar historical experiences. If anything the Chaouïa people are more rudimentary, but their language owes more to Arab influence than does Kabyle, because they live in closer contact with the nomadic caravan life of the Sahara. But, like the Kabyles, they are essentially men of the mountains; reference to a map showing the distribution of the two peoples elicits clearly the correlation between Berber settlement and altitude.[2] There are very few Kabyles, and still fewer Chaouïas permanently domiciled beyond the physical limits of their respective massifs. However, within the Aurès, the Chaouïa people are far more mobile than the Kabyles within the Djurdjuras; nor is this very surprising, for the climate conspires with the physique of the country to discourage the Chaouïas from pursuing a purely sedentary manner of life.

Lying between the High Tell in the north and the Sahara in the south, the climate of the Aurès is far from uniform. A three-days' mule journey can provide you with almost every temperature gradation from Alpine cold to tropic heat, for the snow-burdened cedars of Mount Chélia are only 70 miles from the palms of Biskra. The rainfall, nowhere very abundant, decreases very rapidly towards the south. Weather stations are few and far between in the Aurès, but the approximate annual fall in the heart of the country, *e.g.* Menâa, is 16 inches, while on the Saharan fringe it is less than 6 inches and comes entirely in the winter months. Among other things this means that the wads are little more than a string of pools after the month of April, and that the southern half of the mountains, never lavishly endowed with pasture, is parched for the best part of the year.

Even in the central sector of the massif there are few plants which do not

[1] Generally speaking, the proportion of dark-eyed people in the Aurès is only about 25 per cent., though in places it rises to 75 per cent.

[2] The distribution of the Chaouïas does not coincide perfectly with the geographical limits of the Aurès, largely because the peripheral tribes tend to spread out on to the better favoured foothill and lowland pastures, but in so doing they usually become more or less arabized, *e.g.* the tribes living near the Batna–Biskra line of communication.

improve their yield with supplementary watering. Grain, chiefly winter wheat, is grown without irrigation around Arris and Menâa, but it is a poor man's gamble; the wealthier natives are always those with irrigated land. For the most, the land that cannot be commanded by a ditch is at a discount, providing a scanty diet for sheep and goats, and then only during the winter. Watered land, on the other hand, fetches up to 40,000 francs an acre,[1] although I doubt whether many natives own even as much as half an acre of such land. For the privilege of drawing water for six hours from a single channel the size of an ordinary street gutter the Chaouïas think nothing of paying 250 francs. The control of the channels is in the hands of the village council (*djemaa*) presided over by the civil head of the community, the *amin*, who is responsible to the French for the good management of the community. As these native deputies are paid only a nominal salary by the French Government, it is scarcely remarkable that most of them are open to bribery. If, as not infrequently happens, a native prevails upon the *amin* to allocate more water to him than he needs, he will then sub-let the surplus to one of his less well-situated neighbours, at a profit; however since most natives aspire at some time or other to the position of *amin*, they seldom dispute his decisions.[2]

Berber agricultural practice is simplicity itself. The wooden plough does little more than scratch the soil in spiral patterns. Straight furrows are almost non-existent. Mules which are commonly used for ploughing spend much of their lives roped to a pole in the middle of a threshing floor; as they walk round and round, the rope shortens so that the whole floor is threshed out. Perhaps it is for this reason that mules seem to prefer to start ploughing operations around the perimeter of the field and work spirally inwards. As it is customary to sow the crop on the ground *before* ploughing, a good proportion of the seed is not even covered over. Apparently the Berber is not blind to the shortcomings of his arable economy, for at almost every turn he bolsters it up with the rites and ceremonies of his semi-pagan faith. To take only one instance: I arrived one spring afternoon at a village to find that all the men and boys had adjourned to an olive grove nearby for the purpose of "blessing the plough." There were a few ploughs there it is true (one man had *carried* his more than 2 miles in order to make certain of his blessing), but the most conspicuous feature of the gathering was the prodigious amount of food. Upon inquiry I learned that the whole village had clubbed together to buy two bullocks which were, at that very moment, being divided into equal portions—meat, fat, and entrails—among the whole company. In addition there were large wooden basins full of *couscous*, a mush of semolina smothered with a kind of vegetable soup. The latter was devoured on the spot, but the meat was taken home dangling on the end of a piece of string to provide a feast for the family. The man with the plough, which incidentally was sprinkled with blood by the sheïk during the proceedings, was asked if he knew the signifi-

[1] This is higher than the average land values obtaining in the large towns such as Constantine and Algiers.

[2] The keeping of the main canals in condition is regarded as a communal job, each man affected contributing two or more days' labour per annum: the amount being prescribed likewise by the *djemaa*. In mid-Aurès the cleaning is done twice a year: in April, *i.e.* prior to the first general application of irrigation water, and in August, after the main crops have been harvested.

3. Hill village, Menâa, oued el Abiod

4. Cliff village, Rhoufi, oued el Abiod

5. Arris, administrative centre of the Aurès

6. Oued Abdi, irrigated land near Menâa

7. Oued el Abiod, irrigated land

cance of the ritual: all he would say was that there would now be enough sunshine to bring his figs to maturity. As the village concerned was well up the mountain side near the normal cloud base, sunshine was by no means certain to ripen his figs.

Manurial treatment is rare, for dung is too useful in the house to be broadcast over the fields. Mixed with mud it enters into the manufacture of pitchers and pots, into the construction of the hearth and the home itself, while in its dried state it is widely used as cooking fuel. Simple rotations are followed on irrigated land, but they are almost impossible elsewhere as grain is the only crop to yield a harvest without the addition of water. Fallowing, as an alternative, does not appeal to the native if only because it seems to him to imply the waste of a whole year's rainfall.

In the heart of the country the chief irrigated crops are cereals, beans (yielding two crops a year quite often), figs, apricots, pomegranates, tomatoes, nuts, and dates. Yields are on the whole surprisingly good, but few natives find themselves with any marketable surplus. Indeed they are more accustomed to shortage than to surplus, a fact which helps to explain the precautions taken by them for the protection of the ripening fruit. To a man they build themselves rustic booths, sometimes on stilts, in which they pass their nights keeping guard with muskets of antique design. This they do for the greater part of May and June when figs and apricots, two of their most valuable foodstuffs, are coming to maturity. Nor is their vigil at an end when the last trees have been stripped, because the fruits have then to be laid out to dry on the flat roof of the owner's house, and Chaouïa houses are so arranged that one man's roof is, more often than not, another man's roadway.

By about July and August this long invigilation ceases and there is little more to be done on the land until the winter rains set in. As the wads are now dry and pasture is unobtainable locally, these Berbers are compelled to drive their animals to the better-watered ranges of the northern Aurès. In the extreme south, this seasonal migration begins as early as April, for irrigation water is scarcer and less reliable here and is used almost solely for grain crops; but whether early or late, it is essentially a communal affair. To those who have not seen it, this migration presents a spectacle difficult to conjure: it is the spectacle of a whole community, even a tribe, complete with arms, baggage, domestic animals, flocks, and children on the march: one might almost say, in flight. It is a sight at once impressive and pitiable; "the Bible come to life, or a menagerie on the move, according to the humour of the observer or the eye with which you regard it" (Georges Rozet). Some families take tents, some live in houses which are unoccupied except during the short summer season, while others live, like troglodytes, in caverns [1] hewn out of the mountain side. As the general elevation of the northern Aurès is between 4500 and 6000 feet, some of the land falls well below the tree-line and the limit of cultivation; in fact the pastures are characteristically interspersed with stands of pine, cedar, and scrub oak, and with patches of ploughed land. Those southerners who "own" cultivable land here usually come up in

[1] When these caverns (*afri*) are sufficiently big, the Chaouïa use them as night shelters for their herds as well as their families.

advance of the main body in order to get their grain crops in as soon as the snows have cleared.[1]

By October the Chaouïas are ready to leave their "summer houses," cafés, and shops and return south. But their wanderings are not finished; in November they go off to the oases near Biskra to gather their crop of dates; every native likes to own at least a couple of palms in the desert.

What happens to the village while the Chaouïas are away? Most of the houses are shut down and their contents removed to a communal storehouse known as the *guelâa* (*qal'a*).[2] This is the architectural *pièce de resistance* of Barbary. Built of mud, stone, and date-palm timbers, it is often three to four storeys high and occupies the most easily defended position in or near the village. Many a *guelâa* is only accessible by scrambling up the face of a cliff, or by a really hazardous ascent of a rope ladder; for the storehouse, it should be noted, becomes the village castle in time of trouble. In this semi-arid country there are many hungry people who find it hard to resist the temptation of plundering the *guelâa* of an almost deserted village, and usually they are very well worth plundering. For instance the one at Baniane in the oued el Abiod [3] has fifty-five separate chambers, approximately one for each family in the village; in these chambers are stored the year's crop of fruit and grain, and in addition such household goods, *e.g.* carpets, as cannot conveniently be taken to the summer pastures. However he is a rash man who would burgle a *guelâa* single-handed. In the first place he would need to dispatch the armed guardians of the place, for the villagers never dream of leaving their storehouses unattended. Secondly, he would have to cope with fifty-five different locks, the keys of which are with their owners on the high pastures. By the time he had forced the doors he would be almost certain to find some one had contrived to close the one and only exit, and that his sole chance of escape was to trust himself and booty, if any, to the rope ladder.

The defence factor has also been at work in the planning of the Chaouïa village, but man cannot live by defence alone; in the Aurès, as we have seen, he lives as much by irrigation. Yet the wads which from earliest times have given life to his crops have also given him the Roman, Vandal, and French invaders and the no less dangerous Arab nomads. Even after the subjugation of the country by the French the Chaouïas still had to protect themselves from certain of their own tribes, notably the Beni-Mâafa and Beni-Ferah. It is this perennial division of interests which is largely responsible for the two characteristic kinds of native settlement, the *dechra* (*deshrah*) and the *mechta* (*meshtah*). The latter is usually a collection of houses or tents grouped over

[1] Chaouïa migrations must not be confused with the much larger Arab migrations. These start earlier, last longer, and, incidentally, are a cause of considerable anxiety to the Chaouïa through whose country they normally proceed. He is sure to find himself a chicken short, perhaps even a sheep, when he comes to gather them in at nightfall. The Arab, furthermore, is not so much interested in the high mountain pastures as in the wide wheat-lands of the Tell: these he helps their European owners to harvest. The subsequent transport of the grain by camel to market and town provides him with a full-time occupation until late autumn, when he returns to the Sahara.

[2] Not all the *guelâas* are communal: some natives prefer to build their own personal *guelâas* in well-protected spots near their homes.

[3] The oued el Abiod is the home of the *guelâa*. The Abdi, lying to windward of el Abiod, is better watered and the need for transhumance normally does not exist there.

8. Arab merchants passing through Chaouïa country

9. Chaouïas migrating to the high Aurès

10. Route Nationale crossing the oued el Abiod, S. Aurès

11. Guelâa, Baniane, oued el Abiod

12. Interior of guelâa in Aurès

13. Street in Chaouïa village, Menâa

the cultivated lands of the valley floor or anywhere the Chaouïa possesses agricultural land. The *dechra*, on the other hand, is nearly always perched on the heights overlooking the wad; its houses cling precariously to the valley slopes and rise in irregular tiers one above another. Frequently the *guelâa* occupiesthe topmost tier. In the gorge of el Abiod the *dechra* is generally found "incrusted" on the flanks or summits of the vertical cliff. Approach to it is by almost invisible goat tracks, slippery paths, and miniature platforms along which one advances with some hesitation. The *dechra* is protected moreover as much by its invisibility as by its situation. Seen for the first time from a distance, whether under grey skies or in the glare of the midday sun, it can be descried only with difficulty, for all the houses are the colour of Aurasian earth and stone of which they are constructed. It needs the oblique rays of the evening sun to throw them into relief and reveal their presence to the unsuspecting traveller.

Only at the extreme southern end of the Aurès where the mountains sink beneath the sands of the Sahara, do you find, as at M'chounech (Mshunesh), a union of the *mechta* with the *dechra*. The defensive part of the settlement, occupying a spur of the now low-lying Ahmar Khaddou, merges imperceptibly into the *mechta* located alongside the oued el Abiod.

Altogether there are well over one hundred villages in the Aurès: most of them do not exceed a thousand inhabitants, but Menâa, one of the largest, has upwards of two thousand. Since the pacification of the country towards the end of the nineteenth century, the Chaouïa population has almost doubled.[1] Even so the average density per square mile is less than forty, including Europeans.

And what of the impact of French civilization upon native society? "Assimilation" is the order of the day, but such is the strength of tradition among the Berbers that this process is perforce very slow; all the same, assimilation, early or late, is the goal of every administrator. In education, to consider only one field of colonial enterprise, this means that all teaching, even in elementary schools, is in French. It means moreover that the curriculum is substantially the same as that employed in the metropolitan areas of France. In spite of a strong practical bent, much of the instruction is ill-adapted to the necessities of native life. Thus boys attending a school, whose only contact with civilization is a radio set and a bi-weekly postal service, are taught to produce and print their own magazine; there are plenty of errors, needless to say, but nobody is going to notice them in a country where many people still cannot distinguish between one letter and another. The girls, when they attend, are taught knitting, laundering, European cooking, and table etiquette —arts bearing no relation to the primitive appointments of the native house which is as bare of furniture and linen as it is innocent of sanitation.

At the same time many schools can boast fine experimental gardens where the French masters are annually proving the value of new crops, such as green vegetables and temperate orchard fruits, chemical fertilizers, scientific rota-

[1] In 1936 the population of the three "Communes mixte" into which the territory of the Aurès is divided, was given as 145,765, but as these communes embrace a good deal of the foothill country populated partly by Arabs and Europeans, this figure cannot be regarded as anything more than a very generous estimate of the Chaouïa population.

tions, and terracing for want of which the hillier land is rapidly declining in productivity. Unfortunately the native is slow to copy such good examples. His fields are full of stones that would make magnificent retaining walls for terraces, but he would not dream of disturbing them: "Allah put them there; let no man remove them." Again, when he is given seed potatoes by the French authorities he merely adds them to his evening bowl of *couscous*.

In brief, the Berber's main interest in "culture" is to learn enough French to get him through his three years' conscription in comfort and perhaps enable him to take a temporary job in one of the big cities, such as Constantine, Algiers, or even Paris. And a surprising number of Berbers, Chaouïas, and Kabyles alike, do emigrate temporarily. It is not uncommon to find 10–15 per cent. of the adult male population of a village away from home. Most of them will be engaged in menial work, scavenging, and car-washing for instance, which none the less offers good pay by native standards. The younger men often stay until they have accumulated enough money to buy their brides—a good-looking woman costs anything up to 2500 francs—and settle down on a piece of land in their old village. You might imagine that residence abroad would educate them up to a higher plane of living, but while it is true that some acquire a taste for iron bedsteads, tables, oil lamps, and the like, most of them remain content to spend their nights rolled up in a homespun rug on the hard dung floor, and to eat their food out of a common wooden bowl by the light of a smouldering, chimney-less fire.

By and large, the Berber still lives in the same way as his forefathers. He still settles disputes by blood feuds, with the aid of professional assassins. He still practices a most sinister form of medicine: the recognized cure for bleeding is a poultice of gunpowder, cow-dung, and henna applied to the affected part. Moreover he is still pagan at heart and almost everything he does, from ploughing to plundering, requires the use of charms and incantations. In such a world it is not to be wondered at that French and Berber find themselves perpetually at cross-purposes. On at least one point however there is general agreement between them, for what could be truer than the Berber proverb that

> "Teaching boys is like ploughing earth,
> Teaching men is like ploughing rock,
> Teaching old men is like ploughing water"?

Notes on illustrations

1. A characteristic stretch of the lower oued el Abiod which has gouged for itself a course through the Tertiary sandstones and limestones formerly filling the basin of Beni bou Sliman. This basin separates the Djebel el Azreg from the Ahmar Khaddou. The crests of the latter range, of lower Cretaceous age, can be seen in the distance. The mountains are sparsely covered with scrub tree growths, mostly oak, juniper, and cedar. In addition there are clumps of zerophytic thyme, and a plant known as *armel* (*peganum Harmala*) which gives off a nauseating odour; this last plant is in steady demand by the Chaouïa sorcerers for the manufacture of their poisonous love-potions. The authorities employ *gardes forestière* to restrain the depredations of men and animals, but the *gardes* are few and the mountains wide.

2. The *guelâa*, storehouse-fortress, is characteristic of the drier south-eastern

parts of the Aurès where the absence of summer pasture forces the population to migrate to the better-watered mountains to the north.

Guelâas vary in size and lay-out according to the needs of the community, but they are always found occupying the most easily fortified position in or near the village. In this instance the *guelâa* is built where the cliff forms a re-entrant, the *dechra* (village) adjoining it on the south side. Apart from a narrow defile which links the *dechra* with the outer world, the only approach to this *guelâa* is by way of a rope-ladder let down for the purpose.

Most of the houses are two-storeyed, one side being left open, for use as a look-out, with just a leaf-covered screen for protection against the heat.

3. Menâa has a population of more than two thousand and is larger than most Aurasian villages. For the past forty years it has had a French school (boys only) and since 1933 a hospital which for some obscure reason, certainly not because there was no need, had not been used down to 1939. There is still no postal or telegraphic communication with the village, but it enjoys the benefits of a *bordj* or rest-house, provided by the French for the use of travellers. In addition to a communal feeding-room, it contains private sleeping quarters, a luxury unknown in any Chaouïa home.

The flat-topped houses are "water-proofed" with a bluish clay with which the Menâa area is well endowed; but the life of the roof, used as it is for many purposes, is not long. In fact Chaouïas build nothing that endures. Their houses seldom last more than a hundred years, and many of those which are inhabited are in an advanced state of decay.

4. Owing to the ease with which the sandstones can be fashioned, and to the convenient thickness of the strata, the villages in the oued el Abiod contain more stonework than is general in the Aurès. Many of them, as in the picture, are perched perilously near the abyss, nearly 300 feet below; others appear to have been constructed on a ledge made for the purpose; others yet are built in the living rock itself. Formerly some of the caves were also used as factories for the manufacture of gunpowder, which assumed big proportions at the time of the Chaouïa revolts in the 'seventies of last century. Cities of refuge these, but the Chaouïa women must descend night and morning to draw water from the perennial springs at the foot of the gorge.

5. Arris, the administrative centre of the Aurès, in the valley of the upper el Abiod, strikes a very discordant note in a land of dun grey mud and stone hovels.

Before the coming of the French the valley was uninhabited (the Berber settlement of the same name is perched high up on a bluff overlooking the valley) except when, after rain, it offered valuable pasture. But thanks to the enterprise of a French administrator who was struck by the numerous evidences of Roman occupation, *e.g.* olive presses and irrigation canals, the area has been given a new lease of life. Acres of olives have been planted and reservoirs constructed. Among the results already achieved not the least valuable is the equitable division of water among the many contending parties, and an end to the quarrels, with their risk of civil strife, which formerly surrounded the water question.

6. This is one of the most fertile riverine areas in the whole of the Aurès. The terraces which are watered by channels tapping the Abdi above Menâa are fine examples of Berber patience and care. The loose earth and rubble brought down by the wad in former times is fortified by rocks, boulders, tree trunks, and even bits of Roman masonry. More than one monumental stone commemorating the exploits of Roman legions in these parts is to-day doing good service reinforcing native retaining walls. In addition to growing cereals, usually barley, and vegetables, the terraces are dotted with apricot, fig, and pome-

granate trees. Date-palms are also to be seen in the picture, but owing to the frost hazard this fruit is not regarded here as a serious proposition. If they yield any harvest at all, it is usually fed to mules.

Note the un-irrigated, but still terraced, land above the wad. This is given over to a catch-crop of barley; the yield is uncertain, but usually held to be worth while.

7. Hollowed-out tree trunks, one of which can be seen spanning the dried-up wad to the right of the picture, are in general use for conducting irrigation water over ravines; cedar wood is most often used, as it is very durable and immune to insect attack.

At this point, near Tifelfel, the gorge widens to give the only sizeable flood-plain in the whole of the oued el Abiod's course.

8. In late April and May, when Arabs come up from the Sahara to help with the wheat harvest on the Tell, they frequently carry a "pay-load" of dates, salt, and wheat which they exchange with the Chaouïas for dried fruit and vegetables. The recognized rate of exchange is 1 kilogram of dates (poor quality) for 3 kilos of dried fruits, such as apricots or tomatoes. Some merchants by-pass the Chaouïa country and deal only with their compatriots on the Tell. In this case a date-grower from, say, Biskra will carry on a good camel up to 350 kilos of dates which he exchanges for 700 kilos of corn. This of course means that he will require two camels. (In this connection it is to be noticed that only two of the four camels in the picture are carrying boxes of dates.) If on the other hand a northern corn-grower should go south with 350 kilos of corn, he could reckon on getting 700 kilos of dates in exchange. Thus on his return he could barter these for 1400 kilos of corn. But the journey would have cost him ten to fifteen days' hard labour.

Nowadays however it is common to find middlemen buying up dates and corn, giving to individual growers what is regarded as a fair market price.

9. In the south of the Aurès, where this picture was taken, the annual migration to the high pastures starts much earlier than, say, around Menâa. As soon as the grain crop has been gathered—tree crops, all except the date, are out of the question owing to the scarcity of irrigation water (the grain relies on the winter rains)—all those families which can be spared move southwards. This party, the vanguard of a much larger caravan which might easily stretch in a continuous line for a couple of miles, was well under way by the end of April.

10. Communication within the Aurès is still poor and inadequate. The Route Nationale linking Batna with Arris and Biskra is unmetalled for most of its course, but here and there it is excellent (see Plate 8). Bridges however are almost non-existent, and the crossing of half-dry wads by ordinary cars is attended with considerable risk. Although the oued el Abiod does not flow in this neighbourhood for more than two or three months in the year, deep-rooted trees like the pomegranates and palms in the picture are never short of moisture.

11. The *guelâa* at Baniane, built on the rim of the gorge of el Abiod, has fifty-five separate chambers on three floors in which are stored the wealth of as many families. The chambers are arranged, honeycomb fashion (see Plate 12), round a central courtyard. There is no staircase, only a few projecting beams of date-palms which play a large part in the construction of the building. At the various storeys there are rickety galleries made out of mud-bedaubed laths of wood resting precariously on the structural beams. Along each gallery there are small doors locked by cunning devices, mostly in wood and very complicated, but incapable of standing any great pressure. The interior of the store-chambers is arranged in orderly fashion and gives the impression of a certain affluence; alfa bags and domestic pots stuffed full of grain, dried apricots, tomatoes, etc.,

line the walls, while carpets, rugs, and other valuables which cannot easily be taken up to the high pastures cover the floor.

The flat roof of the *guelâa* is used as an observation post as well as for drying the fruit which could not be stored away in time for the summer trek.

13. Chaouïa "streets" are simply unpaved alleys, no attempt being made to smooth down the rough surface of the outcropping sandstone strata.

In contrast to most Moslem communities, women are given the freedom of the town; only those Chaouïas who have been in Arab country and have learnt their customs insist that their wives should be veiled.

Note the ruined tower in the distance. Practically all villages in Chaouïa territory have at least one such tower commanding a wide view of the surrounding land. From this vantage point in former times the watchman could apprise the village of an impending tribal attack. To-day they are simply historical relics.

DISCUSSION

Before the paper the PRESIDENT (Field-Marshal Sir PHILIP CHETWODE) said: I have to introduce to you this afternoon Lieutenant G. H. T. Kimble, who in peace time is a lecturer in Geography in the University of Reading, and a student of Historical Geography. The Society will remember that he was responsible for the learned Memoir accompanying our reproduction of the Este World Map, which is displayed this afternoon in the Museum. Lieutenant Kimble made a particular study in the years before the war of the Berber Settlements in French Africa, and will this afternoon give us some of the results of his studies.

Lieutenant Kimble then delivered the lecture printed above, and a discussion followed.

The PRESIDENT having invited questions or comment.

Admiral Sir WILLIAM GOODENOUGH asked what was the value of the franc when Lieutenant Kimble was in the Berber Settlements, whereupon the lecturer replied that then the franc was worth about 1 1/2*d*.

Dr. HUGH SCOTT: Many years ago I travelled in some parts of the Berber country, but only more or less casually, in comparison with our lecturer. As Lieutenant Kimble said, the people are nominally Muhammadans, but in few of the villages did there appear to be any distinctive building set apart as a mosque. Some forty years ago it was said that the inhabitants were never a horse-breeding or horse-riding people. Does that distinction still hold? In the photographs I saw donkeys, mules, and even camels, but no horses. Thirdly, I can recall some instances of depredation by the Barbary monkeys, the so-called Barbary Apes. Could the lecturer say whether he saw in the districts he visited bad depredation by Barbary monkeys?

Lieutenant KIMBLE: Every village I visited, and I am told it is universal among the Berbers, had its *djemaa* or mosque. Most of them are little larger than the ordinary Berber house and commonly adjoin the *thejmath*, or village meeting-place. Minarets which are a feature in most eastern countries are rare, especially in Kabylia, and are of rude construction.

There was not a horse in any of the Berber territories I visited. I think a few horses are used for riding purposes, but not for driving. The mule is much more useful to the Berbers because of its greater resistance to the particular type of climate. There is a very clear division between Berber and Arab country in this respect, as in many others. Generalizing, one can say that the Berber country ends where the fig trees, olives, and tiled roofs end, and that the Arab

country begins where thatched roofs, wheatfields, and horses first appear. There were very few Barbary monkeys in the Eastern Atlas. I saw about two, and they were up in the scrub forest areas. Very few natives complained about depredation by the monkeys.

The PRESIDENT: The natives apparently carried no weapons except the assassin's knife. Do the French forbid them to carry weapons?

Lieutenant KIMBLE: The French do not allow the inhabitants to carry arms, so they do not wish ever to be found with weapons on them. Nevertheless, every man owns a musket, which he keeps in his house underneath the dung floor or in the wall. And I was told that every time a boy is born and at every marriage the muskets come out and a volley is fired unless the gendarmes are about. The inhabitants do not carry weapons because if they were asked to submit to an examination by the French authorities and a firearm was found on a man it would mean a term of imprisonment.

The PRESIDENT: It now remains only for me to thank the lecturer. You will all agree that we have seldom heard a more interesting lecture; there was not a dull moment from beginning to end. We do indeed thank him very much.

MAP PROJECTIONS AND SUN COMPASSES

Meeting of the Society, 12 May 1941

I. AN OBLIQUE RECTANGULAR CYLINDRICAL PROJECTION

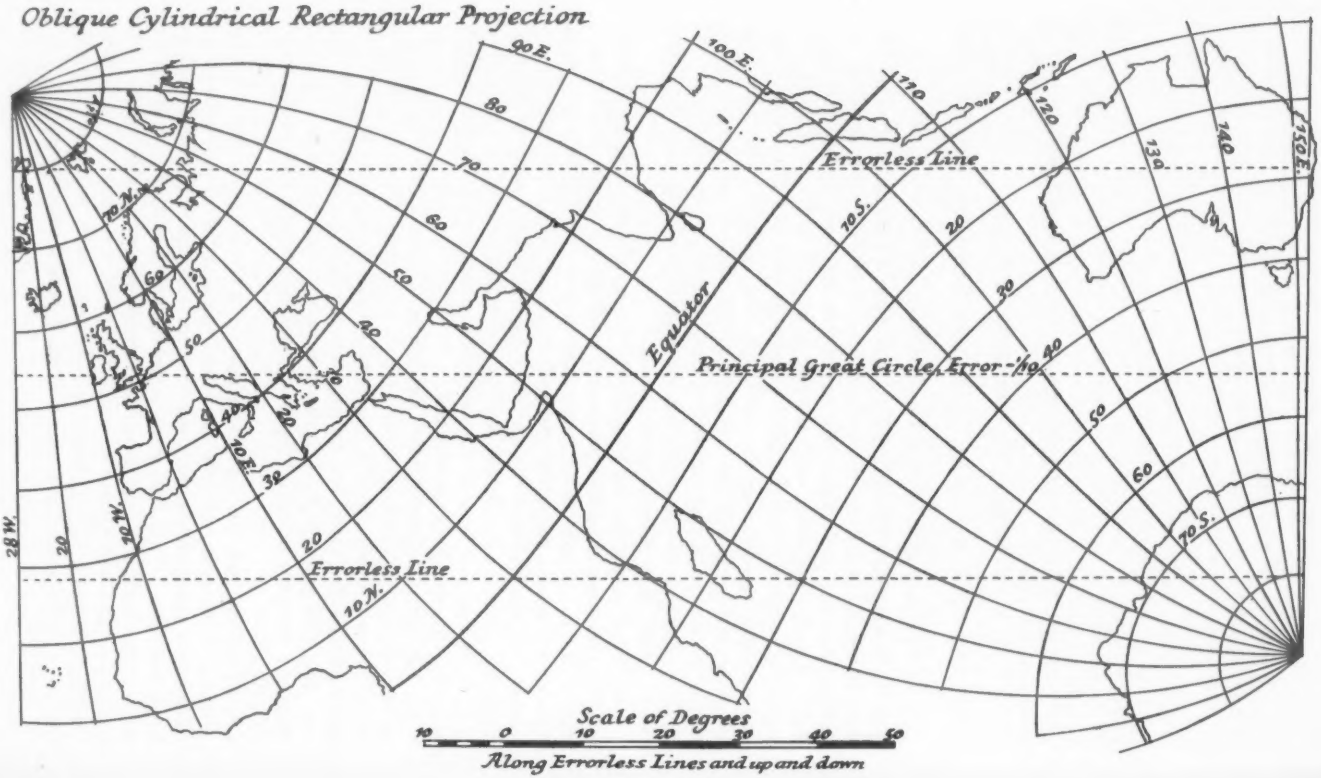
COLONEL SIR CHARLES ARDEN-CLOSE, K.B.E., F.R.S.

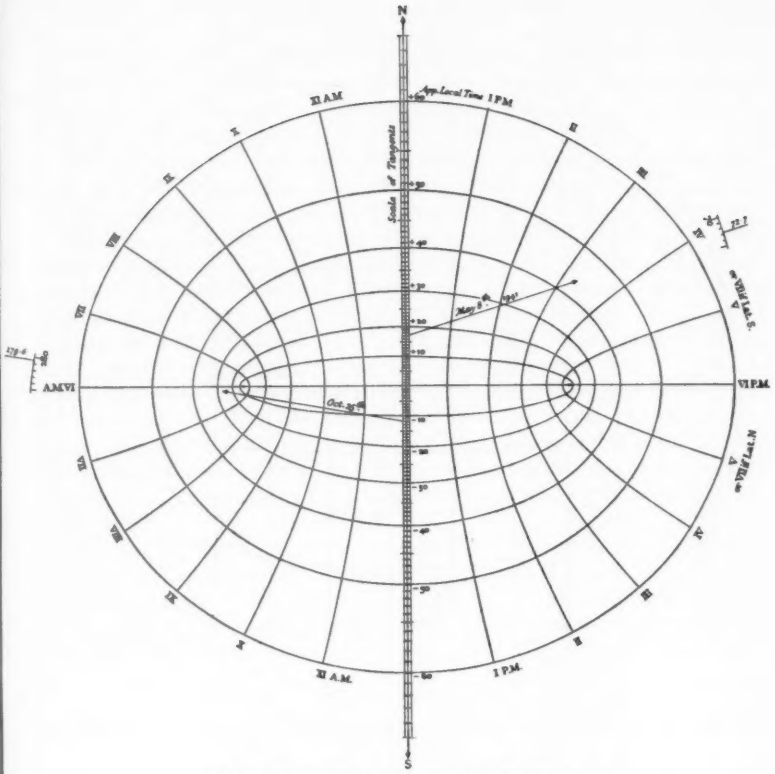
IN the *Geographical Journal* for May 1940 there is a valuable article by Mr. A. R. Hinks describing the construction of maps of the world on an oblique Mercator projection. The article was illustrated by an interesting sketch of such a projection, with the pole at 35°·5 N. and 148° W. The projection had originally been intended to have the pole 152° E.; the alteration only involved re-numbering the meridians. Mr. Hinks calculated the projection for intersections of the meridians and parallels at 10-degree intervals, and in the course of the calculations he obtained the coordinates for the simple cylindrical oblique projection, the simple cylindrical being the "plate carrée," which is an assemblage of squares.

This simple projection can be improved for certain purposes by choosing some parallel, other than the equator, and making the scale along that parallel correct, and it occurred to the present writer that it might be worth while constructing such a projection, particularly as Mr. Hinks had already calculated the coordinates of the simple cylindrical oblique projection, which would only require a simple modification to give the "rectangular" projection. Mr. Hinks most kindly lent the tables of coordinates that he had already computed: a somewhat laborious task.

For this present "rectangular" projection, it was decided to choose a parallel of no error, such that the error of scale along the oblique equator should be 10 per cent., that is, the lengths along the equator will be nine-tenths of their true value, and the errorless parallel being a parallel with the pole at 35°·5 N. and 152° E. This errorless parallel will be at such an angular distance x from the inclined "Equator" such that $\cos x = 0{\cdot}9$; x is therefore 25° 50′.

If we wish to limit the scale errors parallel to the inclined equator to plus or minus 10 per cent., then the outer limit will be 35° 6′ distant from it, and we can draw a projection rather more than 70° wide, round the world, with no larger scale error. This zone, going round the world, will show nearly 60 per cent. of the surface of the globe. All measurements at right-angles to the inclined equator will be true to scale. The projection shows Great Britain, the Mediterranean, Egypt, India, and Australia, with relatively little distortion. The projection is of course on the spherical assumption.


Oblique Cylindrical Rectangular Projection
90 E.
100 E.
110
120
130
140
150 E.
Errorless Line
70 S.
Equator
Principal Great Circle, Error 40
10 N.
Errorless Line
28 W.
10 W.
10 E.
Scale of Degrees
10 0 10 20 30 40 50
Along Errorless Lines and up and down



Richards' Sun Compass: confocal ellipses

II. A UNIVERSAL SUN COMPASS

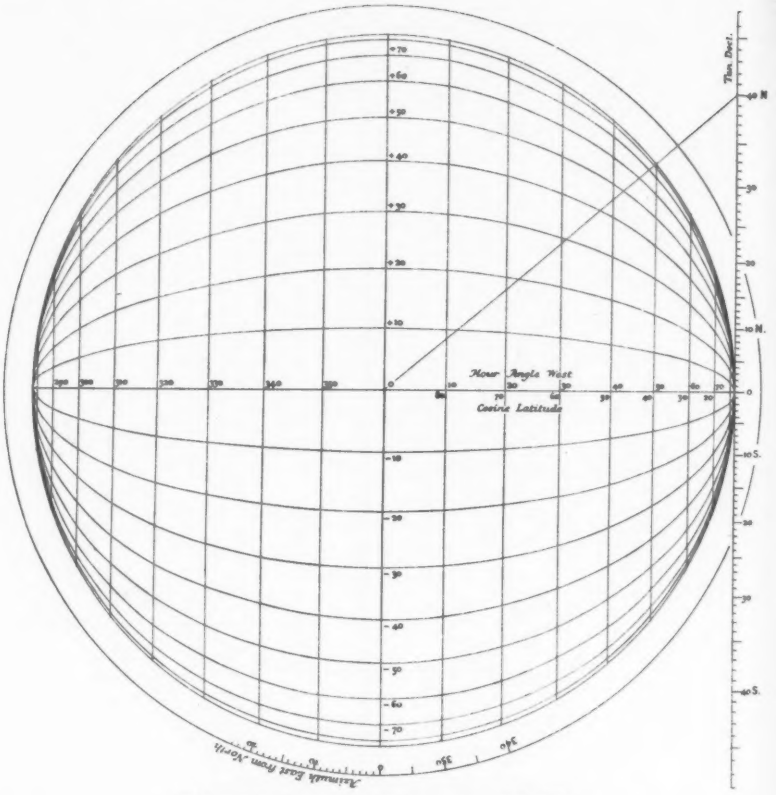
F. S. RICHARDS

In the *Journal* for October 1938, p. 382, there was a note on the E.L. Sun Compass then recently published by the Survey of Egypt. For each belt of 4 degrees of latitude cards were printed showing the direction of the sun's shadow, cast by a vertical gnomon, hour by hour, for every four degrees of declination of the sun. Thus thirteen cards were required for each belt of latitude. It has since been remarked that the thirteen cards for each of eight or ten or more latitude belts may be replaced by one, which makes a Universal Sun Compass.

If t is the Apparent Hour Angle of the Sun, δ the declination, ϕ the latitude of the place, and if axes of rectangular coordinates in a horizontal plane are taken so that the axis of y is north and south, then the shadow of a vertical gnomon at the point $(0, \tan\delta)$ falls across the point $x=\sin t \sec\phi$, $y=\cos t \tan\phi$.

And inversely, if a compass is constructed so that curves of hour angle and latitude are plotted from the formulae

$$x=\sin t \sec\phi, \quad y=\cos t \tan\phi$$



Richards' alternative pattern: co-axial ellipses

and the gnomon can be made to slide on a scale of tangents up and down the y axis, then if the gnomon is set to tan (declination of the day), and the compass is turned in a horizontal plane until the shadow of the gnomon falls on the point corresponding to the apparent time and the latitude of the place, the axis of y is set north and south.

It is easily seen that the latitude curves are confocal ellipses of equation

$$x^2 \cos^2 \phi + y^2 \cot^2 \phi = 1$$

and the time curves are confocal hyperbolas of equation

$$x^2 \operatorname{cosec}^2 t - y^2 \sec^2 t = 1$$

[As was pointed out by Major W. E. Browne in the discussion, this form of the compass is the same in theory as Captain Weir's Azimuth Diagram, published by J. D. Potter in 1880, and described in the Admiralty Navigation Manual, 1938, vol. II, 140, and III, 238.]

The latitude ellipses can be reduced to a family of ellipses with a common major axis by reducing each ellipse of latitude ϕ by a scale factor $\cos \phi$. The hyperbolas then become a series of parallel lines $x = \sin t$, and the diagram is

the orthographic projection rotated 90°. The gnomon must now be placed at a distance $d = \tan\delta \cos\phi$ from the centre, instead of $\tan\delta$, and this distance can be taken from a simple diagram; or by radial to a tangent scale as indicated in the figure; or by radial to appropriate point on the azimuth circle.

Note.—When either of these diagrams is used to make a Sun Compass, the circle on which the compass bearing is read must be centred on the gnomon, and the diagram carried on a plate above it, sliding up and down the y-axis, to set the diagram in the proper relation to the gnomon. And this upper plate must never obscure the azimuth circle. The second diagram is the more compact and is more properly styled Universal, since it covers all latitudes to the poles and declinations up to about 60° with the same ease.

When the diagrams are used not as compasses but for reading off azimuths, the circle may be drawn about the centre of the diagram, and the line Gnomon to time-latitude intersection transferred by parallel ruler to the centre, as in the use of the Weir diagram, which is the equivalent of one-half of the first of our diagrams. As the Weir is arranged it requires precepts for signs and gives azimuths east or west of north or south; but all this can be avoided by drawing the complete diagram and figuring the azimuth circle from north by east to 360°.

If the circle is figured thus, from compass North, it serves as the compass circle: the parallel through the centre must then be drawn in the direction opposite to the gnomon-shadow to give the azimuth of the Sun. If the diagram is used solely as an azimuth diagram for sun or stars the circle is better figured as in the second diagram. ED. G. J.

III. MORE WORLD MAPS ON OBLIQUE MERCATOR PROJECTIONS

A. R. HINKS, C.B.E., F.R.S.

In a note published a year ago I mentioned some advantages of the Oblique Mercator Projection for the study of world problems (*Geogr. J.*, 95, 381). A plane map has many advantages over the globe, on which one cannot easily measure distances or lay down lines; it is impossible to make tracings from a globe or to see both sides of it at the same time. That note was illustrated by the first of a small series of maps designed to show different aspects of the world, of which one or the other might serve for studying any problems that arise. It is desirable to use a cylindrical projection so that the representation can be continuous; desirable to use the orthomorphic projection because it helps in compilation and drawing and solves great circle problems. These are among the reasons why the normal Mercator is so much used. But world maps should show the poles: hence the choice of a small series of oblique Mercator projections in place of the single normal one.

The first map of the series was published on an adequate scale in the *Journal* for May 1940. With the aid of a grant from the Leverhulme Trustees I have now been able to complete many more, and give on the plates small reproductions of six, to be considered merely as sketches to illustrate how the continents lie. The pole of the central oblique great circle has the same lati-

tude 35½° in all. By renumbering the meridians, which is of course equivalent to changing the longitude of the pole, we have a series. Originally they were planned for equal differences 60° of longitude, but preliminary sketches showed that this step in longitude might be modified advantageously to avoid unnecessary distortion in one continent or another. The gratícule was calculated and plotted originally for intervals of 10° in latitude and longitude. At a distance from the central axis it was necessary to calculate the intermediate 5° points, and the intermediate parallels and the meridians were sketched in where they were most wanted. These additional calculations have since been completed for the whole projection, but the results were not plotted when the first sketches were made, as will be seen upon the reproductions. The original six were lettered A to F. Examples whose longitudes have been shifted out of this regular series are designated by the original letter followed by an asterisk.

Map A, Pole 152° E., shows very well the relations of the poles of the earth to the adjacent lands. This was the first drawing made, for it will be remembered that the enterprise started with an eye to the Polar Exhibition at Bergen. Representation is particularly good for the South Polar regions. In every map of the kind some continent or the other must suffer; here it is South America and Eastern Asia.

B, 212°, reproduced last year, suffered particularly in the west coast of North America, which lay along the top margin and was shown nearly three times its proper length. By changing the longitude of the pole 10° we have:

B*, 202°. The change has much improved North America, but has done nothing for Africa, which has even lost the resemblance to the Venus of Milo found by an indulgent critic.

C was drawn for longitude 272°, but again the west coast of North America has suffered, and by changing to

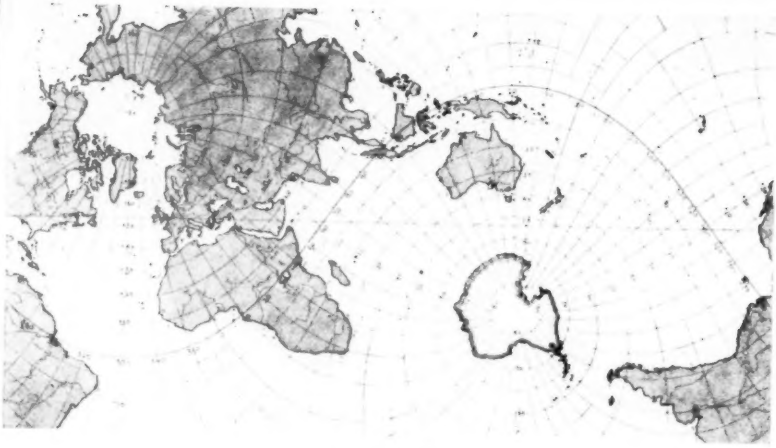
C*, 292°, we include the whole Pacific and can study very conveniently the relations of Europe with that ocean.

D, 332° E., gives South Africa, Southern and Eastern Asia, and the whole eastern coast of the Pacific along the central belt of small distortion. This is an aspect of the world that no globe, nor any map other than an oblique cylindrical with this pole, can give. We have used this map for the study of great circle problems below.

E, 32° E., is the best of the series for the relation of the Americas with the North Atlantic and the Pacific. It is particularly useful for studying the volcanic line bordering the Pacific. One should remember that the map can be cut in halves vertically and the halves interchanged to get a continuation either way.

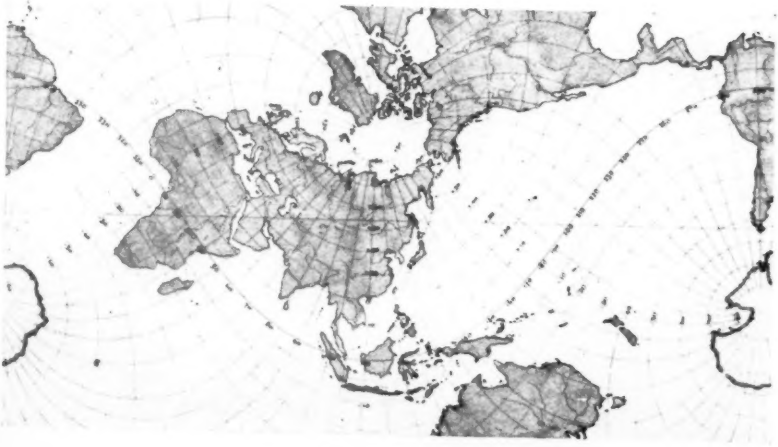
F, 92° E., is good for the world relations of the United States but an especially bad example of distortion in South America.

The calculations of such a projection are long and I am not sure yet whether the best formulae have been developed. For a particular case with the pole in latitude 28° there are the tables published by the Lund Observatory (*Annals* No. 3, 1932) for the conversion of equatorial coordinates into galactic coordinates. These give the coordinates for the intersections of every degree for an oblique simple cylindrical projection. The x coordinates remain the same for

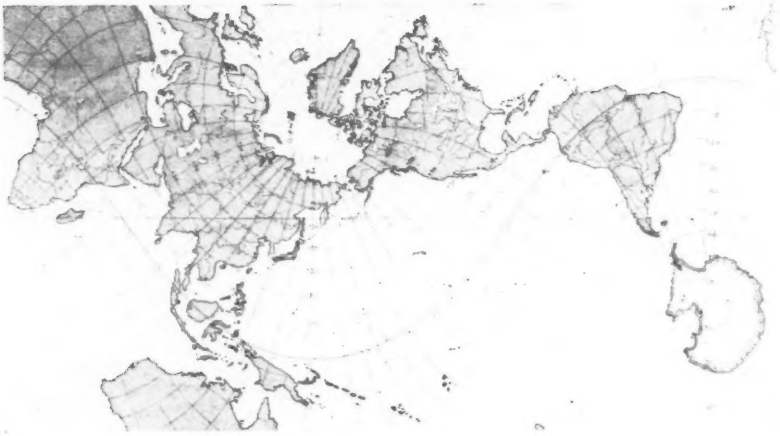


A. 152° E.

B. 202° E.*



C. 292° E.*



D. 332° E.

E. 32° E.

F. 92° E.

the orthomorphic; the y coordinates are quite easily transformed by a table of Meridional Parts or its equivalent. By some accident I remarked that if the pole of the oblique Mercator were chosen in 28° N., 165° E., the caps of radius 20°, which are outside the limits of reasonable representation, lie entirely in the sea. Hence the whole land surface of the earth can be represented upon one map, of which a first sketch has been drawn and is now reproduced in the folding plate.

On the other side of the same sheet is the Transverse Mercator graticule (T.M.) with meridians 10° apart, but divided into thousands of kilometres instead of 10°, and numbered continuously from 0 to 40,000, the quadrant being as nearly as may be on this scale 10,000 kilometres. Each of these meridians is a complete great circle of the sphere, and any curve interpolated proportionately between them is also a great circle. To sketch the great circle between any two points on an oblique Mercator projection, take a piece of tracing paper and trace the horizontal axis and the points to be joined. Put this tracing over the T.M. with the horizontal axes coinciding, slide it along until the two points lie in the same proportion between a pair of meridians of the T.M., and sketch in on the tracing this intermediate meridian. As this is a great circle on the T.M., it will also be a great circle on the oblique, so long as the axes coincide. Hence if the tracing is replaced on the oblique projection, the meridian sketched from the T.M. is the great circle required.

The process is illustrated by two diagrams on the folding-plate. To draw on Map D the great circle London to San Francisco, proceed as above with the tracing paper. The axis and the points lettered L and S.F. on the T.M. represent London and San Francisco with reference to the axis, and they are placed proportionately between a pair of meridians. They are on a great circle of the T.M., and when the trace of this is taken back to Map D it is the great circle required. The length of the great circle between London and San Francisco is found by estimating the kilometer readings at each end and taking the difference. If it comes out more than 20,000 kilometres, we have gone the longer way round; we must replace the tracing on the T.M. and trace the meridian the other way.

The power of the method is shown by finding the great circle between Manila and Valparaiso on Map D. The figure shows that when the above construction is made the desired great circle goes down vertically from Manila to the southern pole of the projection, and comes back again from infinity as a parallel line to Valparaiso. The kilometre readings at M and V are 3450 and 21150. The distance Manila to Valparaiso is therefore 17,700 kilometres and is measured quite simply, though the line on which it is measured has gone to infinity and back again in the interval. Manila is just below 15° N., Valparaiso is 33° S. One would not guess from the ordinary Mercator chart that the nearest way from Manila to Valparaiso is across Australia and south of New Zealand, nor can one see it on a globe, since the distance between them is 17,700 kilometres and they are nearly on opposite sides of the globe. To draw the great circle one would naturally use Maps A or B*; but though Map D is as unsuitable as possible for this particular example, it gives the right result and shows that the geometry is sound.

Or consider the proposition, easily verified even on Map D, that the great

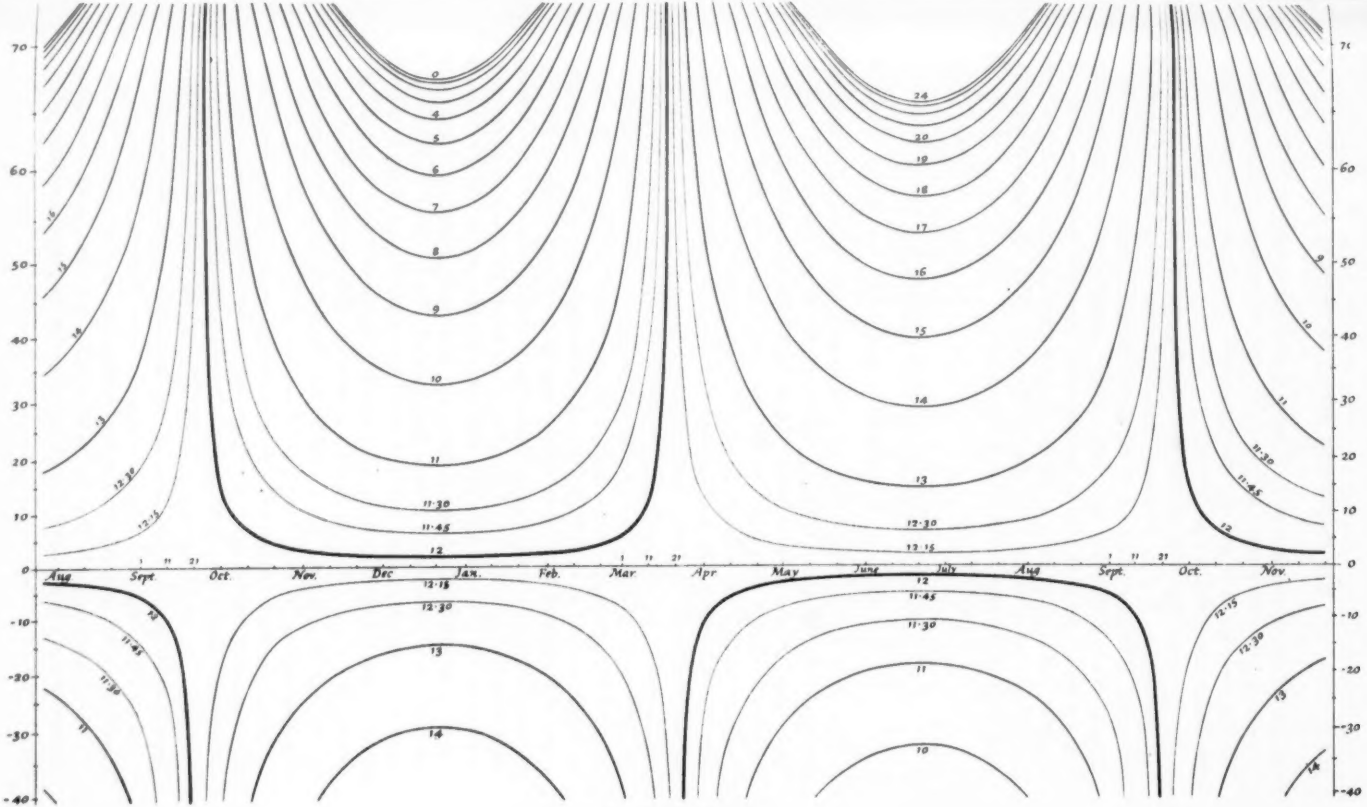
circle from Suez to Panama passes close to the northern point of New Zealand. We have drawn for this the complete great circle. From Suez by Libya, Tunis, Morocco, and across the Atlantic to Panama comes out about 11,600 kilometres. By the longer way round, over Arabia, south of Ceylon, and across Australia it is about 16,150 kilometres to Cape Maria van Diemen, and on to Panama another 12,250. The segments of the shorter route diverge, which means only that to see the route properly the Map D and T.M. should be thought of as cut in halves, the halves interchanged, the count on the T.M. begun from Panama at 34,000 and ended at Suez with 45,600, adding 40,000 to the kilometre figures on the left-hand half of the T.M. to allow for it being moved over in imagination to the right of the right-hand half. In practice of course this is not necessary. If one reads Suez at 5600 kilometres and subtracts from Panama at 34,000 it merely gives 28,400 as the longer way round, and one subtracts from 40,000 for the shorter distance.

By such construction then one can easily sketch the great circle joining two points, however badly placed, to within about half a degree on the sphere, and long distances within about half per cent., which is good enough for plotting world flights or studying beam-radio transmissions. On Map L (land surface of the world) one can plot at least the beginning and end of the great circle joining any two points of the land surface, some oceanic islands excepted; read off the great circle distances, and with a protractor one can take off azimuths from the nearest meridian to a degree or two.

IV. DR. J. R. BAKER'S DURATION OF SUNLIGHT DIAGRAM

Some two years ago Dr. J. R. Baker, of Oxford, sent us a copy of the *Proceedings of the Zoological Society of London* (vol. 108, Ser. A, Part IV, February 1939) with a paper by him on "The relation between latitude and breeding season in birds," and a diagram showing the seasonal changes in the length of the day in different latitudes. The length of the day is defined as the difference between the time of sunrise and sunset, computed as in the *Nautical Almanac* for the refracted upper limb of the sun, which is on the celestial horizon when the unrefracted centre of the sun's disc is in zenith distance 90° 50′. For some years the *N.A.* has shown the times of sunrise and sunset for each day of the year for latitudes up to 60°, and has lately in supplements extended the range of latitude to 73°.

In such high latitudes the determination of sunrise and sunset may be very delicate at the seasons when perpetual day or night are beginning and ending; a small change in the sun's declination makes a great change in the time; the sun will rise one day and not set again for months; and the figures for the same day in consecutive years will be very different. But all this is concealed by the consequence that the curves for a day of twenty-three hours and for perpetual sun come very close together, and one would have to plot on a much greater scale than is convenient, to make the figures evident. In such high latitudes however the exact time of the geometrical setting is of small interest or significance, owing to the irregularities of the visible horizon on land, and the complications caused by dip of the horizon at sea. For most purposes a



Sunlight diagram

small-scale diagram such as we have plotted after the pattern set by Dr. Baker, but with a few refinements, will serve for most purposes; we are indebted to him for the idea of it and for the suggestion that it may find among geographers a wider field of usefulness.

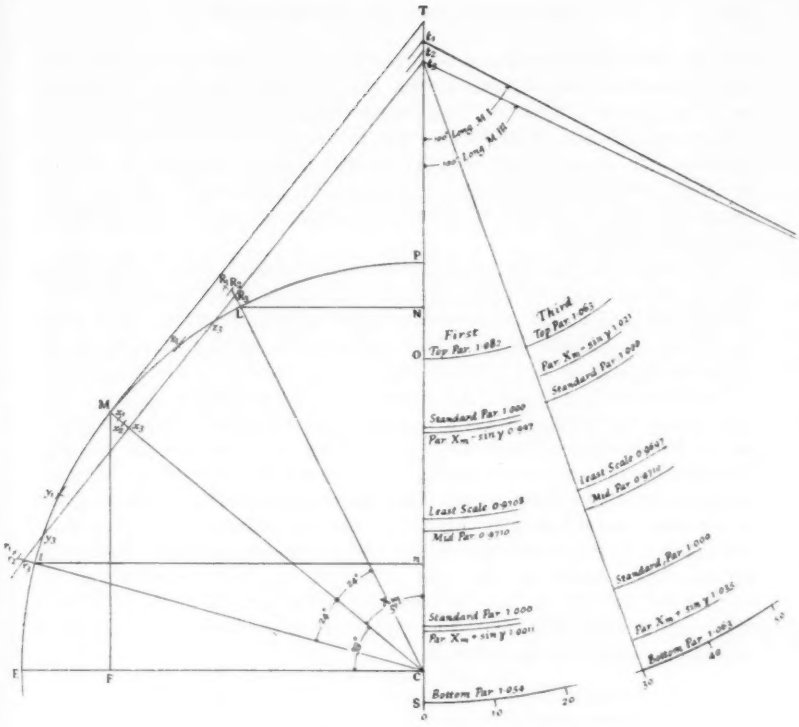
The present diagram is plotted from the data for the year 1941, which are calculated in the *N.A.* to the nearest minute, so that the duration of sunlight, being the difference of two such tabulated quantities, may be in error by a minute. Such differences have been largely smoothed out in the plotting. The curves for north and south latitudes are not quite symmetrical, since the summer half of the year is seven days longer than the winter, but it has not seemed necessary to carry the diagram beyond 40° S.; the time required to make it proved longer than one had expected. A. R. H.

V. MURDOCH'S THIRD PROJECTION

A. R. HINKS, C.B.E., F.R.S.

The Rev. Patrick Murdoch was a Scotsman but Rector of Stradishall, Suffolk, a mathematician, and a Fellow of the Royal Society. In 1758 he sent a paper to the Royal Society "Of the best Form of Geographical Maps" which was read on February 9 in that year and published in the *Philosophical Transactions*, vol. 50, Part II, p. 553. "In most maps," he writes, "we find these two blemishes, *the linear distances visibly false*, and *the intersections of the circles oblique:* so that a quadrilateral rectangular space shall often be represented by an oblique-angled rhomboid figure, whose diagonals are very far from equal; and yet, by a strange contradiction, you shall see a fixed scale of distances inserted in such a map. The only maps I remember to have seen in which the last of these blemishes is removed, and the other lessened, are some of P. Schenk's of Amsterdam, a map of the Russian empire, the 'Germania Critica' of the famous Professor Meyer, and a few more. In these the meridians are straight lines converging to a point; from which, as a center, the parallels of latitude are described: and a rule has been published for the drawing of such maps. But as that rule appears to be only an easy and convenient approximation, it remains still to be inquired, *What is the construction of a particular map, that shall exhibit the superficial and linear measures in their truest proportions?*" Murdoch then draws a figure to make a conical projection of a zone of breadth 2δ with co-latitude of the central parallel χ_m (we modernize his notation); the meridians are divided truly and the total area of the map is true.

About the same time Mr. William Mountaine sent a letter to the Secretary R.S., of which the whole or part was read on April 6, eight weeks later than Murdoch's paper. The late Mr. A. E. Young in his Memoir "Some investigations on the theory of map projections" (R.G.S. Technical Series No. 1), says that Mountaine challenged Murdoch to make a perspective projection on the cone in which the area of a zone is true. There is no trace of such a challenge in Mountaine's letter as published, but an addendum to this letter by Murdoch (p. 568) begins, "If it is required 'to draw a map, in which the superficies of a given zone shall be equal to the zone on the sphere, while at



the same time the projection from the center is strictly geometrical' . . .", as if the problem had been proposed. Murdoch gives the solution which, being a perspective from the centre and consequently producing unequal spacing of the parallels, "hurts the eye," and he adds in a line and a half the rule which defines (incompletely) his Third Projection.

These projections of Murdoch's were discussed by Tobias Mayer (1794), who professed to find faults in Murdoch's theory, and by Albers (1805), who, according to Germain, showed up their defects; Germain (1866) gave a disparaging and quite inaccurate account of them; Driencourt and Laborde (1932) described them briefly without comment; and Sir Charles Arden-Close has pointed out to me that Murdoch's Third is the same as one suggested to him by Colonel A. R. Clarke, in which the mean length of all the parallels is made correct, which is equivalent to making the area of the zone correct, as the meridians are their true length ('A sketch of the subject of map projections,' by Major C. F. Close, 1901, p. 29). Young speaks very highly of Murdoch's projections, and considered his Third the best of all projections of the class. But so far as I can discover no one had ever calculated either of them to make a map.

One day the Society was asked by the British Council to produce a map of Europe and the Middle East which should include Great Britain, Aden, and Rangoon, and show Great Britain (away in the north-west corner) the right

way up. The same evening it occurred to me that Murdoch's Third Projection would be very suitable for this purpose, and in a couple of days the map was laid out. We found that the specification necessitated a skew projection and the area to be covered was far from being a zone between two parallels. We chose for the middle parallel latitude 39°, and the limiting parallels (for the computation) 24° on each side, latitudes 63° and 15°. This seemed to provide on the whole the best representation of all the middle latitudes of the map.

We avoided cutting the projection into two unequal parts by not having any one of the drawn meridians vertical. After some doubt we decided that a map of this kind should not have any formal border, since with one it would be difficult to number the meridians and parallels, and a formal frame discourages turning the map round so that the part required is north and south.

The figure on p. 359, for the construction of the projection, is based upon Murdoch's, but adapted to the case of the British Council Map. It seems to me to be the best representation yet devised to show how the so-called Secant-conic projections are made, and related one to the other. Murdoch thinks in terms of a cone tangent along the chosen middle parallel, and then of a parallel co-axial cone cutting the sphere, and defined by the position of the point x where it cuts the radius CM to the mid-parallel. Taking the radius of the sphere as the unit of length, χ_m the co-latitude of the midparallel, and 2δ (in circular measure) as the breadth of the zone to be represented, then Murdoch's three projections are defined by cumbrous expressions which are equivalent to:

First projection	$Cx_1 = \sin \delta / \delta$
Second projection	$Cx_2 = \sqrt{\cos \delta}$
Third projection	$Cx_3 = \delta \cot \delta$

and the radius of the mid-parallel of a projection is $Cx \,.\, \tan \chi_m = a + \chi_m$. In the first and third the limiting parallels are defined by xy or $zx = \delta$ and the intermediate parallels are equally spaced; in the second the parallels of the sphere are projected on to the cone from the centre.

In the first and second the constant of the cone is $\cos \chi_m$, and it is easily shown that the area of the zone between the limiting parallels is true. In the third it is evident that the area will not be true if n is unchanged, since the zone, of the same breadth as the first, is nearer the vertex of its similar cone. Murdoch does not mention this, nor do his commentators, until Young remarked it in 1920 (p. 40).

In the formulae it is necessary to keep the linear quantities in terms of the radius of the sphere as unity, and angles in circular measure. In calculating a projection it is more convenient to express the radii of the parallels in the equivalent of degrees, and for calculating scale values to multiply the constant of the cone n by the circular measure of 1°, 0·017 453. Thus we have for the British Council Map:

Co-latitude of central parallel	$\chi_m = 51°$ (c.m. 0·89012)
Semi-breadth of zone	$\delta = 24°$ (c.m. 0·41888)
Constant of cone	$n_3 = \cos \chi_m \sin \delta / \delta^2 \cot \delta = 0{\cdot}64952$
	$n_3{}^\bullet = n_3 \times 0{\cdot}017\,453 = 0{\cdot}011\,336$

Radius of mid-parallel	$a_3 + \chi_m = \tan \chi_m \cdot \delta \cot \delta = 66^\circ.5670\ (1{\cdot}161813)$
Scale along any parallel of colat. χ	$= n_3^{\circ}\ (a_3 + \chi)^\circ / \sin \chi$
Scale along mid-parallel	$\sin \delta / \delta = 0{\cdot}97101$
Scale along limiting parallels	$\tan \delta / \delta = 1{\cdot}06290$

The projection is calculated for the sphere whose radius, 6371·22 kilometres, is the mean radius of the Earth corresponding to the International Figure (Madrid, 1924). It did not seem worth while to spend time in the initial stages in calculating it upon the spheroid, or even upon dividing the meridians to their spheroidal lengths, since on any such extensive conical projection the errors of scale along the parallels are many times greater than the difference between sphere and spheroid. On this sphere 24° of the meridian is 2668·77 kilometres. The spheroidal distance 63° to 39° is 2669·98, and from 39° to 15° is 2659·57 kilometres. On the scale of 1/11M the difference between these two arcs of meridian is only 0·95 mm.

The lengths of 100° of longitude on the principal parallels of latitude compare thus:

Parallel	63°	Spheroid	460·68 mm.	Mean Sphere 458·94 mm.	Proj. 487·80
	39		787·55	785·62	762·83
	15		977·77	976·45	1037·86

The difference between spheroid and sphere is trivial compared with the inevitable scale errors in longitude of the conical projection, which is moreover on the limiting parallels actually nearer to the spheroid than to the sphere. Calculating on the sphere is therefore good enough.

What was the defect that Tobias Mayer thought he had found in Murdoch's theory I have not had the leisure to discover. But Young was unfortunate when he searched Murdoch's paper for a mistake and found none. Murdoch was perhaps the first to fall into the error which has too often since afflicted the conception of standard parallels on the "secant conic." The latitude of the parallel through z on the cone is not the same as the latitude on the sphere of the identical parallel. So it is meaningless to say, as Murdoch does, that these parallels will be "of their just quantity." The co-latitudes on the sphere are in this example 31°.189 and 70°.811, the co-latitudes of the identical parallels on the projection are 31°.581 and 70°.419, their scale values 1·021 and 1·035. The co-latitudes of the parallels of true length on the projection are 34°.886 and 63°.104.

A very convenient property of this Third Projection is that the scale values are equal along the limiting parallels, and depend only on the breadth of the zone, not at all upon the middle latitude. Hence it is easy to make a table which shows at once what can be done:

Brief table for calculating Murdoch's Third Projection

δ	8°	A	B	C	D
	12	56°.923	0·99676	1·00655	1·00329
	16	56·455	0·99271	1·01489	1·00749
	20	55·799	0·98705	1·02683	1·01353
	24	54·950	0·97982	1·04270	1·02166
	28	53·905	0·97101	1·06290	1·03209
		52·661	0·96067	1·08803	1·04524

The radius of the middle parallel is A tan χ_m; the scale along the middle parallel is B, and along each limiting parallel is C; the constant of the cone is D cos χ_m.

There is not, I think, any other projection for a zone of given depth which can be planned so comfortably or calculated so readily from a simple table like the above.

DISCUSSION

Before the papers the CHAIRMAN (Major-General M. N. MACLEOD) said: This afternoon we are to have what someone has described as a variety entertainment. We are to listen to four papers, the first of which is by Sir Charles Arden-Close on "An oblique rectangular cylindrical projection." That will be followed by a paper on "The universal sun compass," by Mr. F. S. Richards, formerly of the Survey of Egypt. As Mr. Richards cannot be here the Secretary will read the paper for him. Then Mr. Hinks will give a paper on "A series of oblique Mercator projections of the world," and next he will deputize for Dr. J. R. Baker and give an account of his "Length of daylight diagram." Finally Mr. Hinks will make some remarks on "Murdoch's Third Projection."

Without more ado I ask Sir Charles Arden-Close to open the proceedings with his paper.

The papers as printed above were then read and a discussion followed.

The CHAIRMAN: It seems advisable to divide the discussion into three subjects: First, map projections, on which there have been three papers; second, the sun compass, and third, the length of daylight diagram. I invite observations on the subject of map projections.

Sir CHARLES ARDEN-CLOSE: I should like to express what those interested in map projections feel, namely, that Mr. Hinks' studies are really valuable. We have had several illustrations of the work he has been doing, and I hope we shall see more of Murdoch's Projection. When will the British Council map be completed?

Mr. HINKS: It is a very heavy piece of work, but we are hoping to complete it in the course of the summer.

The CHAIRMAN: If there is no one else who wishes to speak on map projections I should like to venture one or two observations. Looking at Mr. Hinks' series of oblique Mercator projections of the World there came to my mind the route that will have to be taken by American ships carrying munitions to Great Britain and also to our forces in the Middle East. I do not know whether it occurred to Mr. Hinks, but one or two of his projections were very well suited to compare the distance which had to be travelled from either New York to Suez or from San Francisco to Suez, one route going from the east coast of America round the Cape of Good Hope, the other from the opposite side of the American Continent, from San Francisco on the western seaboard, across the Pacific and up through the Red Sea. The projections provide a very good comparison between those alternative methods of getting munitions to our Army in the Middle East.

Mr. HINKS: It would be a composite, not a single great circle course, but it would be possible to get the length of each element in five minutes.

The CHAIRMAN: And now I invite observations on the Sun Compass. Mr. Jolly is, I know, interested in sun compasses. Perhaps he would care to comment on that subject?

Mr. JOLLY: Is it correct to say that the ellipse is, so to speak, as the sun goes round at any given time of the year?

Mr. HINKS: The point is that the intersections of the ellipses and the hyperbolas give the direction of the shadow. It is not a question of the path of the end of the gnomon-shadow.

Major W. E. BROWNE: Mr. Richards' diagram appeared to me familiar; it looked something like Captain Weir's azimuth diagram. I am wondering whether it is not one and the same. The Weir diagram enables one to determine the azimuth quickly to about half a degree. It is a chart published by the Admiralty about 40×36 inches in size, and is described in the Admiralty Manual of Navigation.

Mr. HINKS: It would be odd if it had not been used before, but Richards did not seem to have heard of it, and he had been head of the Computing Office of the Survey of Egypt for a long time. I will look the chart up at once.

The CHAIRMAN: And now is there any one who wishes to comment on the Length of daylight diagram?

Major W. E. BROWNE: I have a small point to make on that. In northern latitudes some of the curves had to be left out because of the crowding. I noticed that the projection was an equidistant one in latitude. Surely if the ordinary Mercator projection were used it would give an exaggerated scale in the northern region where it is necessary to have more space in which to draw the curves? While one could not go to the Pole it would be possible to go up to the limit where one got continuous daylight at certain times of the year.

Mr. HINKS: That is a good idea. I had not thought of the use of Mercator's projection for it.

THE RAISED FEATURES OF BILLEFJORD AND SASSENFJORD WEST SPITSBERGEN

W. G. V. BALCHIN

THE Cambridge Spitsbergen Expedition of 1938, with its base at the head of Billefjord, enabled the writer to make a study of what can best be described as a great field laboratory of raised beaches and associated features. It is an area rich in both erosional and constructional forms: raised wave-cut platforms, raised cliffs and shingle beaches, in places up to 300 feet above sea-level, being present except where scree cones have on steeper slopes occasionally obliterated the features. The absence of any detailed work on the area and the ease with which past shorelines may in places be traced, suggested that an intensive study with mapping and levelling might throw light both on the formation of shingle ridges in a region slowly emerging from a glacial period and also upon the "isostatic" recovery of the district. Plane-table mapping was carried out on a scale of 4 inches to 1 mile and numerous lines of tacheometric levels were run. In the following pages it is hoped to give a general account of the existing features, suggestions as to their mode of origin, and finally a brief discussion of the relative changes of level which have taken place as indicated by the levelling.

The region is largely dominated by a series of rectangular mountain masses with steep escarpments, the remains of a dissected plateau some 3000 feet in height. The escarpments, although modified by corrie erosion, have in many cases a buttressed appearance which bears striking resemblance to forms associated with the cycle of arid erosion. In the north the topography is largely obscured by the New Friesland ice-cap, but over most of Dickson Land and Bünsow Land permanent snow is not extensive and apart from the glaciers which come from the ice-cap the main glaciation consists of snow patches and corrie glaciers. The glaciers all show evidence of retreat and wide U-shaped valleys are common.

The rocks of the region are mainly of Permo-Carboniferous age, and over most of the area the limestone and gypsum beds dip gently to the south at 2–5 degrees. Underlying them is a pre-Devonian metamorphic complex. Between the mountain masses lie wide valleys, in many cases arms of the sea, with a general rectangular pattern. A. M. Peach suggested [1] that these valleys were the product of pre-glacial river erosion and that they were drowned by a pre-glacial inundation. On the coastal lowlands however occasional outcrops afford clear evidence of considerable downthrow and show that the physiography has to some extent been determined by block faulting. This suggests that in any study involving isostatic recovery the approach should in the first instance be local rather than regional, and offers a more logical explanation of the wide and rectangular patterned valleys with their steep flanking escarpments. The Campbell range is thus interpreted as a miniature block mountain with fault scarps.

On the east side of Billefjord, Carboniferous limestone and gypsum beds

[1] A. M. Peach, "Pre-glacial platform and raised beaches of Prince Charles Foreland," *Trans. Geol. Soc.* Edinburgh, 1915.

predominate, but to the north the southerly dip produces increasing exposures of the underlying pre-Devonian. On the west side in Dickson Land the Old Red Sandstone is the lowest bed seen, but near the coast both the Lower and Upper Carboniferous are well developed and the Culm beds of yellow sandstone form a marked feature. In Mimer valley the Permo-Carboniferous, here consisting of black shales and cherts, is again found and covers most of the area to the south.

The coastal plain skirting the escarpments is rarely more than 1 mile wide and is made up almost entirely of raised marine deposits, the latter being derived from the local formations outlined above.

The factors mainly affecting the growth of shingle ridges [1] are firstly the supply of material and secondly the strength, duration, fetch, and direction of the wind. In Billefjord and Sassenfjord great quantities of fluvio-glacial material are carried seawards during the summer melting period and shingle complexes tend to arise where streams debouch on to the coastal plain. The absence of vegetation, and intense frost action breaking down the Carboniferous beds, together with the power of the streams, all combine to ensure a plentiful supply of material. Extensive fan or delta distributaries indicate that material is being supplied at a faster rate than can be dispersed by normal marine processes. Such material is almost always of a coarse and heavy character, although a finer type is transported and the streams are normally milky with suspended solids and rock flour. When conditions in Billefjord were calm the water of the Ekholm river could be traced seawards by the suspended solids. The air photograph (Plate 1) shows this and the drift to the north. The sudden and frequent summer flooding induces a steep gradient to base level and may account for the absence of sandy accumulations.

Wind observations have been kept at Green Harbour some 60 miles south-west of Billefjord. These show the predominant direction of the wind in summer to be north-east, and throughout the year from south and south-east. The summer alone concerns us since shingle ridge formation can only occur during this ice-free period. Observations on sixty-five days from late June to early September 1938 revealed that in Billefjord, the chief wind directions were N. 13, N.E. 5, E.N.E. 7, E. 4, S.S.W. 15, S.W. 7. These observations agree with those of the Oxford University Expedition in 1933,[2] the only other summer records available for Billefjord. The disagreement with Green Harbour may be ascribed to the mountains, the winds tend to blow up and down the fjords. Thus S.S.W. and north winds will be of consequence here in the evolution of coastal forms. The northerly winds from the New Friesland ice-cap were the strongest, and this was emphasized when our party was detained on Gips Hook for five days unable to launch the boat owing to the very heavy seas. But the south-westerly winds have a greater fetch, and this, with the ocean swell which enters Isfjord and approaches from the south-west, produces a dominant beach-drift to the north.

Two additional factors are important. Fluctuations of land and sea have altered the level at which marine processes have worked, and shingle formation can proceed only when the fjord is ice-free. According to records at

[1] W. V. Lewis, "Evolution of shoreline curves," *Proc. Geol. Assoc.*, 1938.

[2] A. R. Glen, "Oxford University Spitsbergen Expedition 1933," *Geogr. J.*, 1934.

Advent Bay the winter freeze up has not been so long in recent years. Nevertheless isolated patches of ice-foot were noted in early July: it has been suggested by many glaciologists that the ice-foot itself is an erosive agent so the few examples seen were kept under observation. In this district however the ice-foot, like the snow patches and very probably for the same reason (see below), seems to have little or no erosive power. No evidence was found to alter the view that summer wave action is, and has been, the dominant factor.

This is in direct contrast with some of the early observations on the raised shingle and beaches of Spitsbergen. Thus we find Garwood and Gregory with the following suggestions:

> "Between the main raised beach lines occur numerous smaller wavy ridges, which often resemble the ridges between plough furrows. A few days' observation on shore supplied a simple explanation of their mode of origin. At the end of June the shore of Ice Fjord was bounded by a belt of Fast ice; as it melted, a channel of water was formed between it and the shore. When the temperature fell to freezing point, this water being practically quite fresh, was frozen. Owing to the resistance of the ice belt, the newly formed ice could expand only on the landward side; as the young ice presses against the shore, it pushes the beach material before it into ridges." [1]

Even bar formation and beach drift is ascribed to ice:

> "As the ice grinds along the shore it pushes the beach material eastward, until it has formed a bar which juts out for a third of the distance across the bay." [1]

By 1921 however the observations of Wordie,[2] Tyrell,[3] and others had ascribed to these coastal features an origin more in line with modern ideas.

The raised features (Fig. 1)

The coast falls into four broad divisions. Raised shingle complexes and associated marine levels dominate; next come raised wave-cut platforms; over the remainder there is little or no coastal plain and the scarp slopes either descend direct to the sea or are covered with modern scree cones.

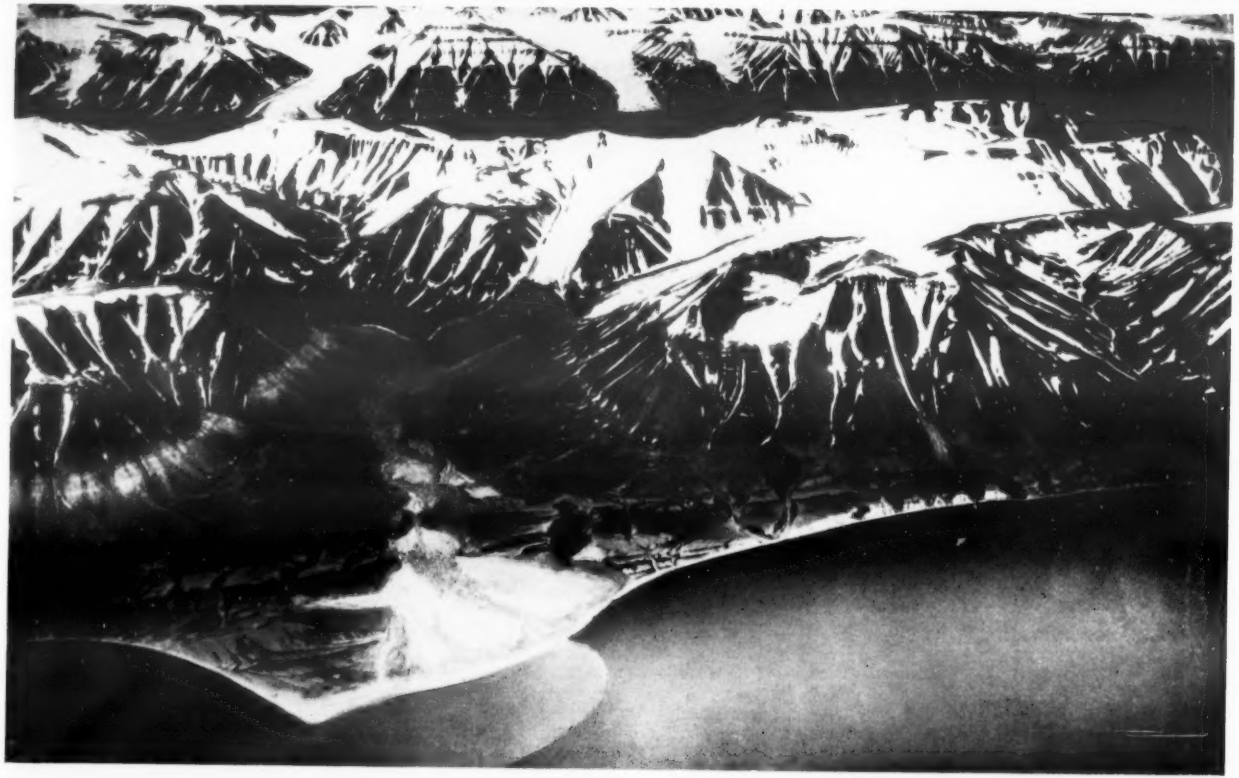
Raised platforms.—These are best developed at the junction of Sassenfjord and Billefjord, where the Gåsöyane (Anser Islands) are undoubtedly fragments of a raised platform of marine erosion (Plate 6). The islands rise to a maximum height of 65 feet and have a general slope to the south-west, the resistant dolerite of which they are composed probably accounting for their preservation. Glacial striae with two main directions of N.N.E. and E.S.E. were noted from the lower levels and seem to be the result of ice from Billefjord and Sassenfjord. Post-glacial icebergs could hardly have produced both the extensive striae and the ice-smoothed surfaces, and there can be little doubt that most of this platform is of pre-glacial age.

The coastal plain of the adjacent mainland from Anser Bay to Gips Bay is similarly a plain of marine denudation emerging directly from the sea. The

[1] E. J. Garwood and J. W. Gregory, "Glacial geology of Spitsbergen," *Q.J.G.S.*, 1898, pp. 214–215.

[2] J. M. Wordie, "Present day conditions in Spitsbergen," *Geogr. J.*, 58 (1921) 42–43.

[3] G. W. Tyrell, "Glaciers of Spitsbergen," *Geol. Soc. Glasgow*, vol. xvii.



1. Cape Ekholm

Phot. Norges Svalbard og Ishavs-Undersøkelser

2. Modern cliff in raised shingle north of Cape Scott (to right) Billefjord. Raised shoreline A to left

3. Raised shingle and tilted shorelines, eastern Billefjord looking north from Phantom Point

4. Raised shingle with polygons, Cape Ekholm. Shorelines B and D in middle distance

platform rises gently inland reaching in three-quarters of a mile a height of 308 feet at the base of Mount Jean: here there are fragments of an old cliff. Glacial striae occur on this platform but are common only on the lower portion, and this suggests that the upper part is possibly of a very late or post-glacial age. The formation of the platform in dolerite would appear to account for the preservation of the pre-glacial platform and also for the absence of other wave-cut features showing temporary sea-levels. For to the east, in the less resistant Carboniferous rocks, the pre-glacial platform has disappeared and a platform at a lower level has taken its place. In the dolerite the relative change of sea-level merely seems to have extended the pre-glacial platform into higher levels.

A very scanty shingle deposit on the platform occasionally takes the form of beach ridges, but material tends to drift away from here either into Sassenfjord or Billefjord, and a bare rock platform devoid of deposits is more characteristic. Gips Hook bears testimony to the force of the northerly waves, for a cliff 40 feet high has been cut in the dolerite. With the gradual appearance of the platform these cliffs are raised above wave action and a further section of the platform becomes subjected to the cutting process: this accounts for the $1\frac{1}{2}$ mile stretch of cliff, some 40–50 feet high, which extends from Gips Hook to the foot of Mount Jean. On first examination this appears to be a tilted erosional cliff related to one marine stillstand; actually it is a succession of innumerable ancient "Gips Hooks" related to many marine levels. There is one exact reproduction of the modern coastline in the elevated part (Map B). The angle formed by this cliff and the foot of the Cowan Range becomes a trap for sediments, mainly of local derivation, and a fine series of shingle ridges at successively lower levels and with a general northerly orientation fills the angle.

On the western side of Billefjord, south of Skans Bay and opposite to the Gåsöyane, is a further exposure of a wave-cut platform. It stretches intermittently to the south of Dickson Land and rises inland until terminated by a raised marine cliff some 100 feet high. No glacial striae were found, but rock exposures are few owing to an extensive growth of vegetation. A correlation of this platform with the Gips Hook platform seems possible, from its position and a similar formation in dolerite. The pre-glacial platform would also appear to underlie some of the recent deposits, for rock exposures were noted from the Ekholm Valley, whilst on the foreshore at Cape Scott recent wave action has uncovered a smoothed rock surface with some glacial striae.

The raised shingle complexes make an assemblage of features which can be described as magnificent, and shingle beaches in perfect preservation are raised in places over 300 feet above sea-level. Three main groups may be distinguished: Billefjord, Gips Bay, and Björna Haven.

In eastern Billefjord (Map A, Plate 1) an extensive development of raised features fringes the Campbell Mountains and Cowan Range, and extends for 10 miles from Cape Napier to below Phantom Point (Skrymtodden), comprising almost the whole coastal plain. A relative change of level has taken place during the formation and marine processes have worked at successively lower levels. Shingle ridges have been built up on the rising front. But during

periodic stillstands, longshore drift and consequent erosion appear to have been dominant, and cliffs were cut in the old raised shingle ridges. With continued elevation the cliffs have been raised above wave action and mark past shorelines; the coast now resembles a series of steps rising landwards to a height, in places, of 250 feet. Movements have not however been uniform and the steps are generally tilted, with a gradient to the north. Streams have cut deep narrow V-shaped valleys across them, whilst the cones of larger glacial streams obliterate some of the raised features: nevertheless the latter, as the map shows, are dominant.

As indicated by Johnson [1] interpretation and correlation should preferably be made on the basis of ancient marine levels or shorelines, and these can be deduced with accuracy only from erosional features. Along the eastern shores of Billefjord, cliff fragments, although known to be tilted, are so extensive that each shoreline can be traced with ease. Six such major episodes may be distinguished (A, B, C, D, E, F, of which F is the modern: Map A), mostly with erosional cliffs of 20 feet upwards (Plate 2). Minor variations occur locally and seem related to slight differences in wind direction during the formation of the shingle ridges; these have been mapped but should not be confused with the major cliffed features. Lines of tacheometric levels were run at intervals along the coast to determine the heights of the raised shorelines. From these determinations the tilts can be calculated. (See below.)

The shingle, of which the ridge pattern is still largely preserved on each step, is fairly uniform in size, being up to 2 inches in diameter throughout. In the higher levels it has been subject to frost action and the typically rounded beach pebble is replaced by angular and sub-angular forms. By digging in the shingle rounded pebbles were always found ultimately, the depth at which this occurred increasing with the elevation.

Stone polygons occur in places but are not widespread, and even when they are superimposed on the ridges the ridge pattern can normally be distinguished (Plate 4). The infrequence of polygons on the ridges suggests either that they take very long to form or that the proportion of fine material and water plays a very large part in their origin, for the shingle, acting like a sieve, does not retain the melt-water. A more recent example of the stability of the shingle is found in Gips Valley, where tractor marks, footprints, etc., made by the Scottish Spitsbergen Syndicate twenty years ago are in a perfect state of preservation.

Solifluction has occasionally destroyed all evidence of ridging, most markedly on the upper steps and less frequently at the base of the marine-cut cliffs. It is remarkable that the unconsolidated shingle cliffs should retain their form so long. They must not be confused with notching produced by longitudinal snow patches,[2] they are definitely of marine origin, as the beach ridges which run up to their base conclusively prove. The porosity of the shingle seems to prevent snow-patch erosion, whilst the absence of finer sediments to act as a lubricant retards solifluction.

[1] D. Johnson, "The correlation of ancient marine levels," C. R. Congress, Intern. Geogr., Paris, 1931.

[2] W. V. Lewis, "Snow-patch erosion in Iceland," *Geogr. J.*, August 1939. L. H. McCabe, "Nivation and corrie erosion in West Spitsbergen," *ibid.*, December 1939.

The distance from crest to crest of the ridges varies from 3 to 5 feet and is fairly constant. Few storm beaches were seen. The ridges are largely unvegetated, but hollows may carry *Saxifraga oppositifolia*, *Dryas octopetala*, and *Cetraria sp.*, with in moister areas *Hypnum uncinatum* (*var. plumulosum*) and *Salix polaris*. Very large included boulders of foreign origin occasionally occur, and are considered to be erratics ice borne from New Friesland, deposited when icebergs from the Nordenskiöld glacier have been stranded on the shore. This process was often observed while we were mapping the ridges.

Turning now to modern conditions: a succession of melt-water streams from the southerly facing slopes ensures a plentiful supply of material; the orientation of the coast being N.N.E. the dominant S.S.W. influence gives rise to a northerly drift [1] and a tendency for the coast to swing out to face the direction of the dominant wave approach.[2] The stone fans deposited by the streams tend to encourage the latter and largely determine the point at which the change takes place. The result is a series of miniature cuspate forelands: Cape Scott for instance is a duplicate of Cape Ekholm.

An interesting illustration of the effect of fetch is seen from Fig. 1; dotted lines have been drawn perpendicular to the trend of the *modern* northerly orientated beaches along the east side of Billefjord. These lines tend to swing round as one passes from Cape Napier to Anser Bay, and the increasing effect of the fjord is felt. The present supplies a key to the past in helping to account for the northerly orientation of almost all the preserved elevated ridges. Erosion during stillstands produced cliffs in the shingle and the S.S.W. facing shores have suffered at the expense of the northerly, where accumulation probably continued to a later date.

The maps indicate the wealth and variety of shore features in the area, but at Cape Ekholm there are several features especially worthy of mention. In the absence of vegetation this region may be likened to a full-scale earth-sculpture tank. It has a series of raised beaches, cliffs, and associated fluvial rejuvenation features: the latter represented by the "cone in cone" structures of the fans and by river terraces which are well developed near the narrow rock constriction christened the Iron Gorge. Three large lakes were mapped south of this gorge, and from the map might appear to lie in an old distributary of the river Ekholm. The existence however of a series of shingle ridges in good preservation between and 100 feet above two of them indicates that the lakes do not lie on an old distributary and have different origins. Geological evidence suggests a minor fault along which recent movement has taken place. The middle lake has an underground outlet and solution in the underlying limestone may be a contributary factor. The small lakes at Bruce City and elsewhere all appear to be the result of depressions produced by thrown-up shingle embankments. The moisture is derived from the winter snow and the permanently frozen ground holds up its dispersal.

[1] Quite apart from the evidence of the shingle the coast is littered with a most amazing collection of driftwood, from barrels and cabin doors to Siberian logs. These increased in number northwards despite the use for fuel by past expeditions staying at Bruce City.

[2] See W. V. Lewis, "Evolution of shoreline curves," *Proc. Geol. Assoc.*, 1938.

South of Cape Scott and near Phantom Point the deep V-shaped valleys cut right through shingle to present-day sea-level; but in the Ekholm Valley, especially east of the Iron Gorge, the shingle appears to form but a thin covering to a rock platform. The latter is probably of pre-glacial age, but no striae were found on the few exposures noted. Eastwards the material grades into a fluvio-glacial deposit of the Ekholm, related to a much earlier sea-level (probably B). Close to Cape Ekholm, itself are several raised capes, which repeat the characteristics of the present cape.

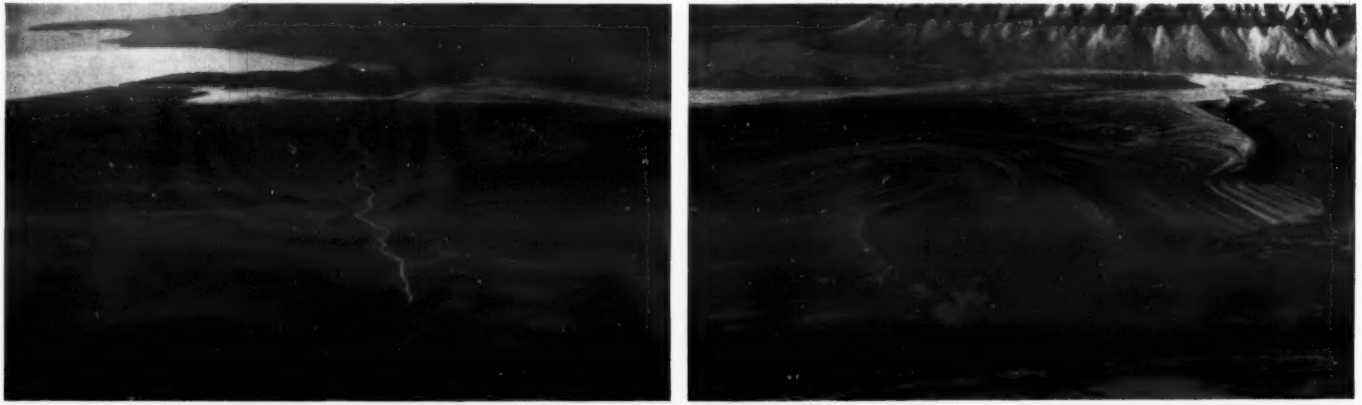
To the north of Cape Ekholm a modern cliff some 80 feet high cut in the raised shingle ridges, gives an excellent cross section of the ridges (Plate 8). This reveals definite bedding of a fine-coarse-fine sequence which can be traced upwards, at a constant angle of 27°, to the shingle undulations of the surface. Measurements on the modern beaches reveal a slope which increases from 5° to 27°. The latter appears to be the angle of rest and is only found near the crest of the ridge. It is suggested that in this case at Cape Ekholm the material accumulated in deep water and has accordingly assumed the angle of rest. The alternation of fine and coarse sediments may be either a seasonal feature or related to the frequency of storms coupled with the supply of material. Similar conditions were noted on the north-facing slope of the Gips valley complex. It is worthy of note because I think no mention of false bedding of this kind, which could be very misleading, has appeared in print.

The second major shingle-complex lies between the Aitken and Usher ranges at the southern end of Gips valley covering an area of some 3 miles by 4 (Map B, Plate 7). There is little doubt that in early post-glacial time Gips valley formed an inlet of Isfjord, parallel and similar to Billefjord and Templefjord; for apart from the height of the raised features at the foot of the Aitken and Usher ranges (which were levelled and found to be 252 feet and 233 feet respectively), wave-cut markings are traceable northwards in Gips valley. Into this inlet, somewhat narrower than its associates, fluvio-glacial material has likewise been poured. At the entrance two fans have formed and wave action has built an imposing series of shingle ridges. This in time doubtless blocked the inlet, and if it were not actually turned into a lake the effective winds were cut off. No shingle ridges were found farther inland than the foot of the Aitken range; to the north, all ridges have been obliterated, if they ever existed. Since no ridge patterns appear to have been cut through by the river Gip it seems improbable that the southern end of Gips valley was ever blocked to form a freshwater lake higher than the mean sea-level of the time. The large lakes shown on Mathieson's map of 1919 are not true lakes but rather flat marshy areas liable to flood when excessive melting occurs, and through which the river Gip flows in a braided fashion.

The eastern part of the valley and bay has a south-westerly aspect and faces a great stretch of water to the entrance of Isfjord. This has been of great importance, for material from the Aitken fan has drifted northwards and has been built up there into a series of shingle ridges. It will be understood that the fan has come into existence only with the successive emergence of the area; in the first place material was very probably deposited in much the same way as is now seen in the younger fans of Billefjord. The highest point show-

5. Bjöna Haven and Templefjord from point m on Map C. Von Post glacier in distance

6. Gips Hook and Gåsöyane Islands, a raised marine platform



7. Gips valley from Mount Aitken (2,000 ft). Map B.

8. Section through raised shingle ridges, Cape Ekholm

9. Rejuvenated valley above Aitken Gorge, Gips valley

10. Scree and fan coast of Cowan Range, Billefjord

ing evidence of marine action on this side is a wave-cut cliff 252 feet above present sea-level. Ridge development becomes predominant westwards from Lake Lillian which has an elevation of 217 feet. Each ridge is at a slightly lower level, and a section across the area has a convex form suggesting that the latter part of the emergence has taken place more rapidly.

The shingle ridges at first flanked the foot of the Aitken range but have since swung round to face south-west; this has been achieved only in recent times and as a result of the upper parts being cut off from wave action by the emergence and growth of the fans, which now almost meet. Shingle development has since been confined to an area to the south. Northwards, before this had happened, the southerly winds had less influence and the ridges are orientated to the north-east, facing straight up Gips valley from which direction the dominant winds would come.

Whilst the area to the east of the outlet of the river Gip has a simple pattern of parallel storm ridges (the largest in the whole area) the region to the west which lies in the lee of Gips Hook and the Anser platform is very complex. The lower parts were more responsive to southerly winds from Sassenfjord, but the higher parts were being built before the complex north of the Aitken fan or the fan itself had arisen, and while Gips valley was still an inlet of Sassenfjord. Hence many of the ridges have a north-easterly orientation and some may even be traced on the top of Salisbury Crags at 330 feet.

The gradual differential uplift (the south rising more quickly), the growth of the shingle ridges and fans, the appearance of the Anser platform, and the gradual disappearance of the sea from Gips valley, are largely responsible for the present topography.

The raised wave-cut cliffs are similarly complex. They are plentiful in the unconsolidated shingle and in harder rock outcrops. The series of parallel cliffs to the east of the river Gip are of marine origin and have not been produced by lateral river erosion as one might suppose. They consist of a series of steps, with truncated shingle ridges and included ponds forming the flats, as on the coast of Billefjord. Some cliffs cut in the unconsolidated shingle decrease in height up the valley and pass into ridges: a change in the direction of the dominant wind, as has recently taken place in Bjöna Haven (see below), would seem to account for this.

On Fig. 1 the sequence of the cliffs is indicated: since the area is known to have been tilted it has not been possible to correlate the shorelines of the Gips Bay area with those of Billefjord, nor the two sides of the valley, although eight major cliffings or shorelines can be distinguished, one above the other, on both sides. We had no time for much levelling here. Gips valley itself should receive detailed study, for much additional light will doubtless be shed on the nature of the region's recovery from the glacial period. River rejuvenation is proved in the terraces cut by the Gip and in the gorges at the apices of the two stone fans (Plate 9).

Eastwards of the Temple range is the cuspate foreland of Bjöna Haven (Map C, Plate 5). The foreland proper has two distinct parts: that to the south of the major cliff *mn* is a series of truncated laterals orientated towards the south-east, with major groupings demarcated by minor cliffs. These appear

to be the product of a south-easterly drift along the foot of the Temple range building shingle ridges facing the south-west; but continued drift has led to a recession of the coastline and only the truncated laterals (related to the south-easterly winds) now remain. These ridges are not much above sea-level, and are probably very recent.

The second part, north of the large cliff *mn*, is a concentric series of major unvegetated shingle ridges falling gradually from 120 feet to present sea-level and facing the full extent of Templefjord to the north-east. The growth of the fan from the Sindeballe range, and the spit which the southerly drift has produced, now protects Bjöna Haven from the full force of the north-easterly winds down Templefjord, and the dominant winds are for the time being from the east. In an effort to readjust the coastline to the new conditions erosion has commenced near Cape Bjöna and the material drifts north to accumulate near the hut. Hence there is a recession near the point, and accumulation follows in the bay as the coastline swings round to face more easterly. Raised marine-cut cliffs are not common, one whose base is 140 feet above sea-level lies to the south-west of the stone fan's apex. The latter has terraces and some interesting rejuvenation forms.

Raised wave-cut features.—Raised cliffs occur near Bruce Hut and Cape Schoultz on the east side of Templefjord, and these, as in the cases already cited, rise to the south. Raised shingle deposits, but heavily eroded, are found north of Cape Rudmose in Petunia Bay. On the west of Billefjord wave-cut etchings were observed on the lower flanks of Mount Pyramid, at the Trappers Hut, and south of Skans Bay. If the latter area is seen from the fjord or from Anser Bay a dip to the south appears instead of the customary northerly trend. Closer examination reveals that this apparent anomaly is due to wave-cut etchings being confined to the harder bands of rock which, as discussed earlier, dip to the south. Wave action has merely served to emphasize bedding, and from a distance isolated cliff fragments appear to join and give a false impression of continuity. In Skans Bay raised cliffs cut in shingle conformed to the general rule. But the coast of Dickson Land is not generally a region of accumulation, very little shingle was noted and no drift-wood.

Scree cone and fan coasts.—Elsewhere, apart from the Nordenskiöld and Von Post glacier fronts, the coast is either precipitous, as for example the Temple range, or built up of scree cones which descend steeply to the sea, as in Dickson Land, the Cowan range, etc. (Plate 10).

The evidence of the included fauna

Little was added by the expedition to the already existing knowledge of the fauna to be found in the raised beaches,[1] but past collections have almost invariably been localized by height. A word of warning is here necessary, for considerable tilting may, as in this case, have taken place. The height of the fauna in such circumstances can be no criterion of its age and past marine

[1] C. S. Elton and D. Baden-Powell, "Raised beach fossils from Spitsbergen," *Geol. Mag.*, LXVIII, 1931.

shorelines as evidenced by destructional features such as cliffs and benches should preferably form the basis of correlation. Collections were therefore made with reference to the various raised shorelines bearing in mind the possibility that some light might be thrown upon climatic change. In making such collections various factors tend to diminish the accuracy. The more delicate fauna naturally breaks up under the conditions of deposition, whilst frost action renders collecting on the upper exposed surfaces difficult, comminution having proceeded at a rapid rate. The possibility of modern shells being transported by birds, and fauna being carried downwards by stream action must also be borne in mind. To offset these difficulties collections were made from near the top of various narrow V-shaped valleys cut by meltwater streams in the unconsolidated shingle. Representative groups were taken from the beaches formed between the periodic stillstands in Billefjord, and the fossils found were as follows:

	Before A	A—B	C—D	D—E	*Modern.*
Mytilus edulis (Linn.)	X	X	X	X	
Chlamys islandica (Müll.) ..	X	X			X
Astarte borealis (Chem.) ..	X	X	X	X	X
Astarte sp.			X		
Cyprina islandica arctica (Linn.)		X	X		
Mya truncata (Linn.)	X	X	X		X
Saxicava arctica (Linn.) ..	X	X			X
Calcareous algae Lithothamnium glaciale					X
Margarites helicina and grønlandica					X
Whale bones			X		

Mytilus edulis inhabits those areas in the tidal zone free from sea-ice and is not found in Spitsbergen to-day. Examples from the modern beach level were undoubtedly derived washings. Its occurrence in the raised beach deposits suggests that the conditions of the formation of sea-ice were different from those of the present day and warmer conditions are indicated.

Astarte borealis was the commonest mollusc from all the deposits. Employing Jensen's method,[1] the living specimens have a length/height ratio of from 75 to 83 per cent. with an average of 78·6 per cent. The samples collected from the upper raised beaches (above A, A—B, C—D) show ratios of 85 per cent., indicating a warmer sea. Specimens from between D and E gave ratios of 96–99 per cent., indicating considerably warmer conditions, this shape being equivalent to the warm form of *Astarte montagui* (Dillwyn).

Cyprina islandica is a species now extinct in Spitsbergen and is characteristic of warmer waters; it is not a common mollusc and has only been recorded on three previous occasions.

The chief conclusion emerging from the analysis points to the formation of all the raised features under more genial conditions than prevail at the present. Whilst the evidence of *Astarte borealis* suggests especially warm conditions (for these latitudes) in the period immediately following upon the

[1] A. S. Jensen, 'Results of the Ingolf expedition,' Lamellibranchiata, 1912.

stillstand represented by the shoreline D. The significance of this will be emphasized later. Finally, in the absence of any definite faunal demarcation between deposits and in the present state of our knowledge, it would appear unwise to attempt a correlation of the beaches based upon faunal content.

The raised shorelines of eastern Billefjord

Tacheometric lines of levels were run perpendicular to the coast at approximately equal distances from Cape Napier to Phantom Point. Heights were initially referred to local high-water mark and tidal observations carried out at the base camp enabled a correction to approximate mean sea-level to be made. The lines are shown on Map A. Sections have since been drawn along each line and from these it is possible to ascertain the height above mean sea-level of the base of each marine-cut cliff crossed by the line. The height and position of the basal points being known, one can draw a section along the coast to illustrate the displacement each shoreline has undergone. The continuity of the raised cliffs (Map A) enables the respective points lying on each shoreline to be joined with confidence and these all appear to lie without exception on straight lines. This suggests a uniform recovery with no actual differential warping. The method is shown in Fig. 2, and this, if allowance be made for the vertical exaggeration, is in effect a view of the shorelines of eastern Billefjord as seen from Dickson Land. The tilts of the shorelines to the southern horizon have been calculated, and along the section chosen are as follows: A 53′; B 29′; C 21′; D 20′; E 4′; F 0′ (modern level). (Plate 3.)

The uniform rise in sea-level (a eustatic movement) which is considered to have followed the termination of the glacial period in consequence of the melting of the ice-caps must undoubtedly ante-date level A, for all these raised features are found in shingle and fairly warm summer conditions must have prevailed before a supply of material for the beaches, and the forces to produce them would become available. This is borne out by the faunal evidence which indicates more genial conditions than exist to-day. This strongly suggests that the tilted shorelines have been produced for the major part by the isostatic recovery of the region, except for the change from C to D, the close parallelism of which suggests a eustatic drop. Such a parallelism could only otherwise be produced by either a uniform and very equal block uplift or alternatively an uplift over a very large area (a regional epeirogenetic shift): neither would seem feasible in this district. The magnitude of the eustatic drop is measurable by the perpendicular distance, approximately 64 feet, between the shorelines. Continuing recovery has imparted to both a subsequent tilt.

The differential recovery does not seem to have taken place about a constant axis or hinge-line, for the point of intersection of B and C is farther north than that of A and B; and the intersection of E and F is farther north than D and E. The presumed eustatic fall separates the two phases. A movement of the hinge-line northwards appears to have occurred and would naturally be expected with the progressive amelioration of the climate and the disappearance of the ice mass responsible for the original depression.

Even the small angles involved in the tilting are sufficient to produce large vertical differences of height in a short distance (53 minutes involves 813 feet

in 10 miles), and since no raised features were noted at a height exceeding 350 feet it seems that recovery is essentially local rather than regional. It may possibly be partly occurring along the already existing zones of weakness in the faults mentioned above, and along which there is, in the Ekholm valley, evidence of very recent movement. The fault blocks are in all probability acting as independent units. Should this be so, correlation between Billefjord, Gips Bay, etc., would only be possible on the basis of the included faunal remains and the difficulties in this method have already been pointed out.

The apparent dip or tilt of shoreline B in azimuth 23 degrees along the eastern shore of Billefjord is 29 minutes. This shoreline rises when traced eastwards into the Ekholm valley and from the measurements made an apparent dip or tilt of 52 minutes in azimuth 295 degrees is revealed. This gives a maximum or true dip of 58 minutes in azimuth 322 degrees. This was the only level which had an easterly extension sufficiently great enough to determine with accuracy a second tilt or apparent dip, and hence from this the azimuth and magnitude of the maximum. It is possible that should the Gips valley complex be systematically levelled sufficient evidence would be available to disentangle the tilts and hence the movements, if any, of the azimuth of maximum tilting.

The evidence from the Ekholm valley adds further weight to the argument that the recovery is local, for if the tilt of level A (the highest) is continued to the west side of Billefjord it passes below sea-level before reaching the coast, yet raised features are found on this western side.

The field data indicates the existence of a pre-glacial platform of marine abrasion, much of which has now disappeared. The maximum glaciation of the Pleistocene period caused a depression of the area under the load of the ice, and when progressive amelioration of the climate released the locked-up waters of the ice-caps, the sea returned to its former level more quickly than the land. This produced either an extension or further erosion of the pre-glacial platform.

The land, slowly being relieved of its ice load, then began to experience an isostatic recovery of an intermittent character, a movement which has continued to the present day. The combination of this with marine erosion and construction is largely responsible for the extensive development of raised features. That much of this is of recent date is apparent, for genial conditions must have prevailed before the shingle complexes could have been formed, a condition which is borne out by the faunal evidence. The complexes although older than those which occur on the coasts of Britain are thus very young geologically. Their mode of origin serves to emphasize conclusions already reached in the British examples studied.

During the isostatic recovery and between levels C and D of Billefjord a eustatic fall of 64 feet seems to have taken place. From the faunal evidence it has been seen that *Astarte borealis* passes into the warm form of *Astarte montagui* after level D, thus indicating much warmer conditions. The similarity of the above sequence with parts of Fennoscandia will at once be apparent and suggests a possible correlation of the Billefjord eustatic fall with the Ancylus Lake and Submerged Forest periods of Boreal age in Europe.

The evidence also points to independent recovery by fault blocks, the movements thus being local rather than regional. This can only mean that for such areas detailed and intensive methods in research must be applied, a conclusion to be emphasized for future investigators. Each unit may prove to have its own special contribution in unravelling the problem of the post-glacial recovery of Spitsbergen.

I am especially indebted to Mr. W. B. Harland, the geologist to the expedition, who kindly undertook the identification of the faunal remains; to Mr. P. M. Pritchard, who acted as staffman throughout the levelling; and to Mr. J. M. Wordie, Mr. J. A. Steers, Mr. W. V. Lewis, and the many other friends who have helped in the final preparation of the MS.

A POLITICAL OFFICER IN PERSIA

SOUTH-WEST PERSIA. A political officer's diary 1907–1914. By Sir ARNOLD WILSON. *Oxford: University Press*, 1941. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xii+316 *pages.* 15*s*

IN 1907 most of the map of south-western Persia was blank or over-printed "unsurveyed." Equipped with a gift of tongues, a hardy body, an enviable disregard of danger, pain, and discomfort, and an amazing capacity for manual or mental work, Wilson set about rectifying this. He walked or rode incredible distances, took his plane-table everywhere, lived on the country, "sweated athirst in its summer heat, frozen and starved in its cold," mapped and collected encyclopaedic notes on all sorts of subjects, and was indeed a model of the complete explorer. His first journey has already been described in the *Journal* (31 (1908) 152), when he set off with a companion, one servant riding a donkey, and the kit on a single mule, to walk from Bandar Abbas to Lar. Water on the early part of this journey was drawn from *birkehs*. These cisterns contain a fluid prepared by the rain-water washing into them mud and the dung of various quadrupeds and bipeds during the occasional winter storms. This fluid then mellows and supports a complicated flora of algae and bacteria, and is the breeding place of guinea worm. However he drank this with no more formality than straining it through his shirt and survived without experiencing ill effects. He bathed and refitted at Lar, which though prosperous in 1907 had relapsed twenty years later to the ruinous state it was in in 1882. Thence he tramped on to Jahrum and Shiraz, then as disturbed as it has often been in the course of its history. It has been a kind of Persian Stirling where the "tails" of the rival clans clashed, and political intrigues were the undoing of many a good man.

From Shiraz to Isfahan, Tehran and Resht the road was too well known to need a survey, so he travelled by the horse-drawn post-cart, sharing it with deputies of the *majlis*. Their conversation and his travels impressed him with the unsuitability of parliamentary government in the east. He wrote "the *majlis* will not work . . . the Qajars or some other dynasty will eventually destroy it and reestablish the old order, but Persian nationalism will get stronger."

Before returning to Persia on duty with a picquet of 18th Bengal Lancers as guard to the drillers on the oil concession, an incident occurred in India when new equipment was issued to his regiment of Sikh Pioneers causing dissatisfaction to the men. Wilson dissipated this by marching with it all, a rifle and 200 rounds, some 34 miles in a single night. As he journeyed from Ambala to Karachi he noted the desert "full of life. Tiny flowers in spring: lizards and insects, birds and even beasts like zebras and foxes that are not to be seen elsewhere. The deserts are so clean and free of biting flies and other plagues and so cool at night that sleep will come to a man in the desert when it would be denied him in the prosperous cultivated area a few miles away." His comment on Muscat's gleaming harbour and coast as " that it is the sort of place Albrecht Durer would have loved," whilst Mohammerah is portrayed as set with deep date-palm groves on either side of the turbid reddish stream of the Karun before it mingles with the clearer waters of the main river, the Shatt al Arab.

His first post was at "Mamatain, where gypsum cliffs are overlain by gravel, indicating a higher river level and smelling strongly of H_2S." Later he moved to Masjid-i-Sulaiman, from which place surveying was started, sometimes in good weather, sometimes in bad with sodden clothes and no fire or tent. He always slept on the ground so as to be able to detect noises more easily and to better avoid stray shots. The country supplied barley bread, curds, dates,

lentils, and rice, with mutton once a week as a luxury, and a good supply of game, including partridges, quail, and pigeon. One early exciting journey has probably not been made before or since, when he drifted down the Karun river through the magnificent gorges between Susan and Bardiqamchi. It took twelve hours on a raft of inflated goat-skins and revealed three ancient bridges in ruins, copious springs issuing from the limestone walls with great fish swimming in clear pools. When the tribes migrated in the spring they crossed this river by rafts when it was in flood. Rarely however a tribesman would swim the torrent unaided, a challenge Wilson could not resist "to show that an Englishman was as good in the water as they." To him, as to all who willingly live amongst them, the hardy ways of the tribal folk made an immense appeal, but few there be who adopt their scanty raiment, a cotton shirt, loose cotton trousers and a loose felt coat without sleeves, sleeping out in it at night even when it freezes. But he did. Their feeding too he adopted and was content with one good meal at night and a handful of dates and bread at midday with water lapped from the right hand as is the custom. "Only townsmen put their noses into the water." The excellence of Persian feasts is superlative and one given by him to the drillers as propaganda to wean them from their habit of living upon tinned stuff made them envious of what "he could afford," only to find it was just the "dirty native food" from the bazaar cooked by their own cook. These feasts are of course not normal meals, but whenever some hard and difficult journey or one involving particular hardship had been completed a goat was sacrificed and he and his men filled themselves with the fresh-killed meat. Living well on native food in Mohammerah cost about 10*d* per day of which about half was profit to the cook. Twenty-five years later a tribal servant lived well for about 5*d* per day, four or five times as much as it cost the poor to subsist.

Animals in the mountains are a fairly varied band of wolves, jackals, foxes, leopards, and bears. The bears are regarded as being intelligent and almost human. One tale was told to A. T. by an "eye-witness" of a bear playing leap-frog over a strayed ass. He in turn assumes this rôle when he reports the meeting with a lion near the Karun river, a genus which seems now to be extinct in south-west Persia. There are large fish in the rivers one of which was occasionally shot, still the usual means of taking them. On the occasion of a bathe in the lower Karun after a long ride the natives watched him with interest, which he learnt was due to the fact that two children had been taken by a shark recently and they wondered if the same might happen to him.

The finding of oil after some drilling at Masjid-i-Sulaiman was a great event which Wilson was the first to announce to his chief by two quotations from the psalms, " 'that he may bring out of the earth oil to make him a cheerful countenance'; 'the flint stone into a springing well.' " His comments upon the company authorities in Glasgow who had demanded cessation of the drilling before oil was encountered and thereby narrowly escaped losing the concession at this time, and their extraordinary lack of objective interest in the area after oil was struck are not flattering. In this and other matters his is the view of the man on the spot, and he sums up by referring to the method adopted "as one of trial and error; trials of the servant abroad; errors of Westminster." There is a mistake of some arithmetical importance regarding the oil well F.7 which produced nearly 7 and not 700 million tons of oil in fifteen years (p. 43). On the matter of figures there is rather a tendency to use a hundred as the Persians use *chihil* (40) meaning a great many. Peaks are described as being seen 100 miles off when their actual distance may have been rather less.

The hot weather in the Masjid-i-Suliman region is an ordeal which Wilson

faced at first in a small tent, but then he made a cave where conditions were better. He found oil lamps would not function because of the flash-point of the oil nor candles because the wax melted. In spite of the conditions he kept fit by eating little and giving his stomach little work to do. During this first summer he journeyed to Kuh-i-Mungasht, travelling by night, and climbed the mountain to 9600 feet to find there was no water as the snow had all melted. From its top the Gulf was visible to the south. At a later date he reached the fort of Dismuk to the east of Mungasht, an exploit of some daring when he crossed a tribal frontier alone but for a servant and made contact with a tribe which was not on good terms with the Bakhtiaris from whose land he had come. He soon made good and won prestige by shooting an ibex at 200 yards. His host inspected the oaks as they rode by to assess the acorn crop which provides the flour from which much of their bread is made.

Before the cool weather came he was also at work in the desert riding to distant villages "of course taking bearings and making notes all day," of old canals, present creeks, and fields cultivated and harvested with the sickle by Arabs living amongst the date groves on the river 50 miles away. He dressed like a Persian and conformed to the customs of his servants but found there was much bigotry amongst the villagers who proclaimed him an infidel on approaching their hutments. The tribes showed none of this antipathy. In the autumn the desert surveys were extended to the east of Ahwaz, where a perfectly flat waterless plain extends engendering the feeling of being always in the centre of this flatness even after several hours of travel. Here the only object in the landscape was the caravan moving upon a waste of fine silt. On the return from such a journey after twenty-two hours without food he swam his horse across the Karun to reach the Consulate at Mohammerah. On this and other exploits of endurance and recklessness he built up a great reputation amongst the tribes as a "man's man." He raced against one young Persian chief, jumping the canals below Dizful on his stallion. He competed creditably though not successfully with rifle and revolver against another in Luristan. He rode 100 miles in a day with only a blanket as luggage to keep a tryst with his chief, and after one day's office work chose a long rough journey to make a fresh map instead of savouring the flesh pots of Ahwaz on a Christmas day. In the first year, by travelling 3000 miles on foot or horse back, he had mapped as many square miles of country.

At the time that the oilfield was being opened up many opportunities arose for surveys as land was acquired for this and that. The river at Ahwaz became more important as a waterway and had to be gauged. Data thus collected became more and more valuable as time went on and dredging and irrigation were in question. Wilson it was who made the first survey of the island where the great refineries of Abadan now stand when in 1908 he became Acting Consul at Mohammerah. The appointment brought little diminution in the explorations which were pushed through without regard to climatic conditions whenever chance demanded it of him. He visited the Karkhah river in June, crossing plains in a sun temperature of 160°, and in September, the most trying month in the Gulf, he investigated the entirely unmapped deep-water inlet Khor Musa at the head of the Gulf. The heat of the salt-impregnated mud was so great that the Arabs found it unbearable. "It was a scene of complete desolation—gulls, fish and mud tortoises the only living things. Mirage in every direction." On a second visit in October to the Karkhah with a British surveyor, Storrs, a map was made by swimming from rock to rock with Wilson at one end of the tape and Storrs at the other. On this trip their men were kept happy by a supply of coffee beans, for coffee is to the Arabs what beer is to the British soldier.

Consulate work detained him at Mohammerah at times when court duties and entertaining of various grades of guests provided a variety in his work which was not previously forthcoming. As Consul he read service and adds a characteristic note that at the Christmas service he read the usual prayers, but not the one for Parliament "which must look after itself." Soon however he was back at surveys for which his ability to get through the unsettled tribal country made him indispensable. Travelling light, knowing the people and their language, were more important than highly specialized training in surveying, when the job in hand was to reconnoitre a route for a railway from Ahwaz to the plateau at Burujird. This involved a journey through Luristan without raising the animosity of the tribes whose unsettled state was aggravated by the feebleness of the Central Government in Tehran at that time. To discover a proper political background he first mapped country not far from Dizful to give him time to learn some of the niceties of tribal politics. The contacts thus effected led to the arrangement of a tribal guard. In spite of many hitches, Wilson eventually reached Burujird, to which his act of leaping the 15 feet wide chasm at Pul-i-Tang with the Saidmarreh river flowing 50 feet below probably contributed more to insure his safety than the guard's rifles. Tradition had it that young men of the tribe sometimes leapt across rifle in hand, but no one in the tribe would attempt it when dared to do so. The tale of Wilson's leap spread almost as rapidly as the gorge widened, and it had reached 30 yards across before his journey's end. This survey was interrupted by a tribal fight in which he played an unexpected part as a magician. By looking at the enemy through his field-glasses he was thought by his men to cast a spell on the others, and men held up his arms when they tired till the fight was won, just as is told of Moses in the Old Testament. The parleys following the fight involved the handing over of mares, mules, and rifles, whilst two "society" marriages were arranged to help to prevent a recurrence of such an outburst in which several tribespeople were killed. As a result of the journey a strip across the unexplored country up to Khurramabad was surveyed, and material collected, to report upon this alignment as a possible railway route.

The district west of Khurramabad has always been disturbed and Wilson's excursions into it were perilous. On the first, he and his men suffered a cudgelling and bought freedom, after acrimonious bargaining with their captors, for £12, watch, ring, and revolver. Nevertheless he was able to extend his triangulation and visit some oil-seepages for the first time besides making contact with the chief of Dilfan. On the second, made with a railway engineer, he fared better by eluding the tribespeople who were endeavouring to seize him as a hostage to offset the prisoners from their ranks taken by the Swedish gendarmes and then in the hands of the government. But it was a perilous passage down the Kashgan valley, in spite of a large tribal guard, including some from the very sept that had molested him before. This is the route now followed by the motor road from Dizful to Khurramabad and one which he reported as satisfactory for a railway, as it undoubtedly is, and one very much easier to negotiate than that up the Diz river along which the present Trans-Iranian line runs. Ruins of three old bridges across the river still stand in the gorges. One of these was built, according to a legend, to give an impatient youth a means of carrying off his bride from her father's fort, yet escape pursuit. By crossing the last span of the bridge on boards which could then be carried away he achieved his objective, nor was that span built up before she had borne him a son and her father been placated.

As variety to these journeys north of Dizful others fell to his lot in the hotter tracts to the south-east, inland from Bushire, where again possible routes had

to be investigated. In the coastal district the capture of rifles by the navy from gun runners had made the British anathema, yet this coast had to be surveyed. This was managed by travel in the hot weather when it was not customary for the thieves to be on the alert, for except by night it is too hot for travellers to be about. In this heat in August Wilson's plane-table was in action and he was moving by day, although even the sea at the once famous port of Siraf where Sindbad called was as hot as could be borne. In spite of warnings he set out for Shiraz through the Qashqai tribal country, surveying the region drained by the river Mund and finding it to be a possible alignment for a railway from Bushire to Shiraz. Turbulance and anarchy prevailed in the border of this terrain, partly in the hands of the Qashqai and partly in those of Baharlu Arabs, so that travel beyond Jahrum was perilous. To avoid being trapped Wilson announced his departure for midday and left before dawn, traversing another path than the one he had said he would follow. About 9 miles from Shiraz he expected to be met by an escort from the town, but was in fact seized by a band of Qashqai, cudgelled, robbed, and taken prisoner. After a night when they tried to make their prisoner's blood creep by relating what was going to be done with him, orders came from the head of the tribe ordering his release and escort to Shiraz. Once there Wilson found a state of siege prevailing, for a political refugee from the Qashqai in the Consulate was in jeopardy of assassination. (It is an odd coincidence that thirty years later direct descendants of this refugee and the Qashqai chief who was seeking his enemy's life should, at the one time, be undergraduates in the same college in Oxford.) When the situation cleared a week later Wilson went to work surveying in the Shiraz area and also made one journey to rescue a looted lady medical missionary, which involved the chivalrous bestowing of all his bedding upon the destitute lady whilst he slept on the stone floor of *serais* for the rest of the journey. In moments of leisure he turned out a report on Fars running to six hundred pages of type, as well as reports of his journey illustrated by the maps he had made.

1912 opened with a daring trek across the ranges from Isfahan to Ahwaz. There is a Bakhtiari proverb of warning against this crossing when the snow is on Zardeh Kuh, but in spite of it, and deep snow accompanied by the low temperatures obtaining in the high ranges of the Zagros in winter, the journey was made safely and in phenomenal time. On the long last day in the mountains he was separated from his servants and his kit, but passed a tolerable night lying between cows resting in a shed.

The next few months were spent on journeys up and down the Gulf and in various consular offices, but surveys of the unknown desert and marshes between Ahwaz and Amarah had to be done at the very hottest part of the year. This involved wading naked in the marsh, swimming the creeks, and boating in *mashhufs*, reed-craft coated with bitumen, but moving everywhere with his plane-table. In these tracts there was much animal and bird life, and the tale of the sand grouse flying to the river to drink and then soaking its breast feathers to carry back water to its nestlings is interesting. The birds sit on the nests by day to protect the eggs from the sun, but leave them at night for quite long periods. Only one other journey to the Dizful region added its spice to office work before he was allowed to go on leave. He worked his passage home as a stoker, and did double shifts through the Red Sea, earning hearty approbation from the Captain and Chief Engineer, and his first complimentary dinner. "None other has given me quite so much gratification." It was given him by his fellow stokers in a brothel in Port Said. He left his ship in Marseilles, bought a cheap suit and second-hand bicycle, and cycled home *via* Le Havre and Southampton to Worcester.

Back in Persia after a journey *via* Central Europe, Constantinople, and Baku, he went at once to restless Luristan, where things were worse than before on account of punitive action by Swedish gendarmes; but, by good luck and good management, contrived to get through from Burujird to Dizful and make various arrangements with the Lurs for a railway survey, which was never carried out on account of the insecurity in a land where "there is no confidence in the present, no pride in the past, no hope in the future, no patriotism except within the narrow limits of the tribe, no bond of religion. . . ."

The toil and enthusiasm devoted during these six years in Persia to map-making and reconnaissance made him invaluable to parties of all the four nations taking part in the demarcation of the Turco–Persian frontier in 1913. Although surveying of a more accurate nature was carried out for this purpose his journeys enabled a difficult part in the marshes to be taken as done. In the early part of the commission Wilson was "cumbered with much serving," but later, in Kurdistan, played a dominant part after the British Commissioner had gone sick. As a side trip he made an excursion from camp to Kermanshah to fetch silver coin from the bank and accomplished the 112 miles in three tremendous days; for half the way he had to travel through steep deeply dissected country of the Sirwan basin before reaching the easy plateau leading to his goal. Wilson describes the return journey as adventurous, and he certainly does not overstate the case. He got through by stowing the coin in sugar sacks, travelling long stages, resting in the open for a time by day so as to arrive at the villages after dark and to leave them before dawn. The villagers were thus kept in ignorance of the weight of these "sugar sacks" and had no urge to investigate their contents after a convenient ambush. The war started soon after and gave all parties an inducement to hurry on. Most of Wilson's staff had gone before the commission reached the slopes of Ararat, but with Colonel Ryder he carried on, and the last maps and protocols were signed at Bayazid. Affairs looked ominous between Turkey and the Allies at this time, and when Ryder went on with the documents the Turks required Wilson to stay behind to furnish them with "extra maps," as a device to delay him till war was declared. This prelude to being taken prisoner and interned Wilson defeated by asking his Turkish colleagues and would-be gaolers to lunch next day and decamping himself after dark, telling his servants he was going to dine with the Turks. He got away leaving all equipment and crossed the Oxus into Russia two hours before Turkey declared war on Russia. He left Archangel on the last ship through the ice that year and *via* London, Malta, and Bombay, was back to work with Sir Percy Cox, who was the author's well-beloved friend and chief, in Basrah on 28 December 1914.

The book has a number of misprints which would not be there had Sir Arnold lived to read the proofs. There is a good index, but the publishers have denied it a map, an embellishment of which it is well worthy. J. V. HARRISON

GEOMAGNETISM

GEOMAGNETISM. By SYDNEY CHAPMAN and JULIUS BARTELS. Vol. I, Geomagnetic and related phenomena. Vol. II, Analysis and physical interpretation of the phenomena. *Oxford: Clarendon Press*, 1940. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* xxviii + 1–542; x + 543–1050 *pages; illustrations and diagrams.* £3 3*s*

TERRESTRIAL magnetism is one of the oldest specialized sciences, in fact, Gilbert's 'De Magnete' has been described as the first modern scientific treatise. Yet, with the exception of several excellent encyclopedia and handbook articles on terrestrial magnetism and a few brief monographs, there has not existed until the publication of the book under review a single comprehensive treatise on the subject in any language. This omission has now been completely removed and we have a work which fills the need most efficiently.

The two authors, Professor Sydney Chapman of the Imperial College of Science, South Kensington, and Dr. Julius Bartels the Director of the Geophysical Institute, Potsdam, form an excellent team; for the former is one of England's foremost mathematicians and the latter is the head of the most celebrated magnetic observatory in the world. The work they have produced is in two large volumes, together comprising over one thousand pages, and treats the whole subject of terrestrial magnetism: history, observations, mathematical discussion, and physical significance. Not the least of their achievements is to substitute for the cumbersome term "terrestrial magnetism" the more convenient "geomagnetism," a term which will no doubt soon be generally accepted. Geographers have a real interest in geomagnetism for geographical discovery would have been a much longer process if the earth had not possessed a magnetic field to direct the mariner's compass; but their interest is not likely to extend to all the contents of these two volumes. The geographer will however want to know what progress has been made in explaining the cause of the earth's magnetism and the present state of our knowledge of the origin of magnetic disturbances and of the relationship between magnetism and other phenomena such as the aurora and sunspots. All these things are dealt with in great detail in the books before us, and a short summary of the conclusions reached may be welcome.

First as to the cause of geomagnetism. Our authors have to confess that at present no satisfactory explanation of the earth's main field is available. All that can be said at present is that there is evidence that the earth is not magnetised by electric currents or magnetic fields which exist outside the earth itself. The origin of the magnetism must therefore be within the earth. The most natural assumption is that the earth is a permanent magnet; but there are insuperable difficulties to this explanation. The interior of the earth is much too hot for any iron there to retain permanent magnetism and no distribution of magnetic material in the cooler crust will explain the local variations of magnetism at the surface. The alternative theory that the earth is an electromagnet is no more successful. To maintain the current of 1000 million amperes which would be necessary to maintain the magnetic field would require enormous electromotive forces, and no such forces are known. The possibility that the magnetism is the direct result of the rotation of the earth has been considered in all its forms; but no physical connection can be found. In the absence of any explanation of the earth's magnetism all that can be said is that the earth *behaves* as though there was at its centre a permanent magnet which does not lie exactly along the axis of rotation; but along an axis which meets the surface in the northern hemisphere in latitude 78·5° N., longitude 69° W., and in the

southern hemisphere in the antipodal point; and that the field of this magnet is locally disturbed by surface rocks and other local inequalities.

As no cause is known of the primary magnetism, no explanation can be given of the slow secular change in the magnetic "variation" (declination) of the compass. Again, all that can be said is that the earth behaves as if the magnet which we have assumed at its centre moved relatively to the axis of rotation in a way the laws of which are not known.

The magnetic field at the earth's surface is constantly undergoing changes in addition to the slow secular change which we have just considered. These changes are of two kinds: periodic and irregular. To the former belong the annual, monthly (lunar) and daily variations, and to the latter the well-known, and often intense, magnetic storms.

More success has attended the attempt to find the cause of the periodic variations than has been obtained in any other branch of geomagnetism. As early as 1882 Balfour Stewart had come to the conclusion that only electrical currents in the upper atmosphere are capable of explaining the daily variations of the earth's magnetic field. He postulated a layer in the upper atmosphere capable of conducting electrical currents, and in support pointed to experiments which had recently been made by Hittorf indicating that highly rarefied air can conduct electricity. If there were such a layer, Balfour Stewart pointed out, then any motion of the conducting air, because it moves in the earth's magnetic field, must give rise to electric currents; just as the movement of conducting wires in the magnetic field of a dynamo produces electric currents. He considered that the motion of the air was brought about by the convective currents established by the sun's heating influence in the upper atmosphere. But of course this was all hypothesis, for there was at that time no direct evidence of any such conducting layer, and no one knew what motion would be set up in such a layer in consequence of solar radiation.

Some years later Schuster took up the further investigation of Stewart's dynamo theory. He calculated the form of air motion one would expect in the upper air from measurements of the daily variation of the barometer at sea-level. He also suggested that the upper air was made conducting (ionized) by ultra-violet light from the sun and therefore would be more conducting on the day than on the night side of the earth; and in the summer than in the winter; thus accounting for the greater magnetic variation during the hours of daylight and in the summer.

Later came Heaviside's suggestion that the bending of wireless waves around the earth would be accounted for by a conducting layer in the upper air, and finally Appleton's beautiful experiments in which he made wireless waves which travelled along the surface interfere with waves reflected from the conducting upper layer, and in this way not only showed the reality of the conducting layer but also measured its actual height, which proved to be about 120 kilometres above the surface. This layer is frequently referred to as the Heaviside layer, but is now always called the E layer in technical literature. Later Appleton discovered another conducting layer some 100 kilometres higher up; this is called the Appleton layer or technically the F layer. Here we have not only the existence of a conducting layer substantiated, but we have also an embarrassment of riches, for now we have two layers in either of which or in both the electric currents affecting the magnetic field may flow.

Professor Chapman has himself been largely responsible for the recent development of the dynamo theory: he has worked out the lines of flow which the currents would have to take to produce the observed magnetic variations and improved Schuster's calculations of the actual air movement in the upper

atmosphere, both under the influence of the sun and of the tidal motion set up by the moon. There are still many difficulties to overcome, but there can now be little doubt that the main periodic variations in geomagnetism are due to currents set up in one or both of the E and F conducting layers by tidal motion of the conducting air across the lines of force of the earth's permanent magnetic field.

The second type of magnetic disturbances, the irregular, is the most interesting, as it certainly is the most dramatic, for to this category belong the great magnetic storms, which visibly affect the compass, disturb electric communication, both wired and wireless, and with which are associated magnificent displays of the aurora. They are so intimately connected with sunspots that it was early realized that they owe their origin to some form of disturbance in the sun. Schuster suggested that a magnetic storm resulted from a sudden intensification of the ionization of the upper atmosphere by an increase in the ultra-violet radiation from the sun; but this gave no explanation of the aurora and was not generally accepted. Recent observations of the sun have revealed sudden outbursts of ultra-violet light which are immediately followed by disturbances of the earth's magnetism; but these are only weak effects and do not last long; they confirm Schuster's idea but do not explain magnetic storms. Birkeland put forward his celebrated theory that the sun shoots out beams of electrons which, passing near the earth, become entangled in the earth's magnetic field and are directed towards the magnetic poles so giving rise, when they enter the earth's atmosphere, to auroras and magnetic storms. To this the fatal objection was made that the electrons in such a beam would be scattered far and wide by mutual repulsion long before they could pass from the sun to the earth. Nevertheless the calculations of Störmer showed that moving charged particles could account for so many of the observed facts that scientists were reluctant to abandon the idea altogether. In 1919 Lindemann proposed a way out of the difficulty; he suggested that the stream of corpuscules from the sun is not composed of electrons alone, but of electrons and positive ions. He showed that such a stream would not fly apart by electric repulsion, and that the recombination between the electrons and ions would not be appreciable. Lindemann did not carry his idea any further; but during the last few years Chapman and his pupils have subjected it to a close mathematical investigation. The mathematical difficulties are very great and only the fringe of the problem has yet been touched; but sufficient has been done to show that qualitatively it can account for many of the phenomena which accompany magnetic storms and the aurora. At the present this is the most hopeful of all the numerous theories to account for magnetic storms.

There has been much discussion on all these questions in recent years, but it has taken the form of highly technical articles in journals which are not easily available. Chapman and Bartels have therefore done a useful service in presenting the whole subject of geomagnetism in a readable and accurate form, for which geophysicists and others interested in the progress of science are very grateful.

G. C. SIMPSON

RIVER CONTROL AND HYDRODYNAMICS IN INDIA

STUDENTS of river action will have much to learn from the first two Research Publications of the Central Irrigation and Hydrodynamics Research Station at Poona (Delhi, 1939 and 1940). Demonstration can be conducted in small "Earth Sculpture Laboratories" like that described in the *Journal* (vol. 89, No. 2) but, as Professor Ogilvie there pointed out, large-scale experiments are necessary to reach quantitative results. In geographical literature, whether systematic or regional, the negligible space usually allotted to the morphology of alluvial plains which is so subtle and so subject to rapid change, bears no relation either to the intrinsic interest of the subject or to the importance of plains as human environments. The experiments recorded also command attention in view of the amelioration of environmental conditions increasingly attainable in India. For they deal with the control of rivers and thus, ultimately, with the restorative or destructive action of floods, whether widespread over plains or concentrated at river banks; and they directly concern both communications, across rivers or along them, and irrigation. It may be added that for lack of hydrodynamics the field of constructional engineering would seem to have been unduly narrowed. Inspection of Indian disasters makes one realize that, in bridging a river, too many an engineer has been content to study his bridge while forgetting the river.

The creation of this Central Research Station marks the Government's recognition of twenty years' outstanding work by its Director, Mr. C. C. Inglis. The station is placed just below the dam of a great irrigation reservoir, Lake Fife. Facilities include clear water, relatively even water temperatures, a slope giving a good head, and constant discharge. By 1938 the length of channels and models already exceeded 2400 feet. "Basic experiments" deal with general problems of turbulence, divergence, silting, seepage, and the like. They are designed both to elucidate principles and verify formulae and to develop constructional technique. "Specific experiments" are those required for the solution of particular, and usually urgent problems referred to the station by a provincial government or railway board. To quote a simple "specific" example, preliminary experiments were made with a model of three Himalayan rivers flowing to the Ganges. The specific problem put by the Government of Bihar concerned the effect of embankments, particularly along the Kosi, upon the changes of a river's channel or channels. It was confirmed that while embankments tend to increase the severity of river changes, they do not cause them. As the whole problem affects agricultural property in northern plains inhabited by perhaps 100 millions whose livelihood depends on agriculture, it is to be hoped that further and fuller guidance may be sought and given.

It is however to key points at which capital has been concentrated that attention is usually called, and with urgency, particularly near irrigation dams or railway bridges. Of such is the Hardinge railway bridge over the Ganges (or Padma) in Bengal. Upon the maintenance of the bridge and its approaches, threatened repeatedly by destruction owing to the shifting of meanders, vast sums had been spent (amounting in one year alone to a million sterling). The railway company's engineers appear at first to have concentrated upon fighting the river's attack at or close to the bridge, with too little regard to the laws of shifting meanders, whereas the solution lies rather in river training, guided by understanding of these laws and of their action along a considerable reach of the river. A dozen previous experiments made at the station on the protection of the Hardinge Bridge had already dealt with a reach of 30 miles. In 1937–38, in order to forecast changes over a number of years, experiments were required

first of all to see if the actual changes of recent years could be reproduced. Although acknowledgement is made to the theory and formulae of Lacey, no one had hitherto grappled with a practical problem of such difficulty and complexity. Hence this "specific" investigation "soon took on the character of basic research. . . ." Correct entry conditions were reproduced by starting the model as from a point 40 miles upstream from the bridge, above Sardah, where the river had not changed its position for over one hundred years. The model was continued to an off-take 12 miles lower down, that of the Gorai. The model was 550 feet long, and the horizontal and vertical scale ratios were 1/500 and 1/65 respectively. The quality of the silt to be discharged was carefully selected, and both the current and the injection and suspension of silt were controlled. By these means, the flood cycles of 1936 and 1937, with the scour and silting of the prototype, were reproduced with general correctness. Simultaneously, experiments were conducted for the perfection of Spring's designs for flexible "falling aprons" of loose stones, and their use against scour, also interesting to geographers for their analogies with nature. Again, to observe how a particular breach had taken place, a glass window was placed in a special model. Near the bank, at the surface, was seen a slow return flow, but at the toe (or base) there was a vigorous forward flow, where erosion was severe and clearly due to surges of high velocity and of fluctuating direction of $\pm 10°$ to the horizontal. Such deep-water observations and the reproduction of cyclic occurrences are notable. For they are bringing within human grasp both the theoretical understanding of rivers and the practical achievement of river training.

Summarizing his principles, in a paper read to the Indian Science Congress (1938), Inglis points out the importance of making the right choice of models upon a sufficiently large scale and the necessity of three-dimensional considerations too often overlooked. He concludes that model experiments are "a valuable aid in solving problems" but that they cannot replace "intimate knowledge of the engineering side and a flair for diagnosis." No one who has visited the station can fail to realize the importance of the Director's own part in its methods and in its progressive achievement. ARTHUR GEDDES

Owing to difficulties of transport, there must be some delay in delivery of this publication in England. Copies for the Society's Library have been ordered through the office of the High Commissioner for India, but have not yet been received.—Ed. *G.J.*

REVIEWS

EUROPE

ESTONIA. By J. HAMPDEN JACKSON. *London: George Allen and Unwin*, 1941. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 248 pages; sketch-maps and diagrams.* 8*s* 6*d*

Mr. Hampden Jackson's 'Estonia' is a companion volume to his book on Finland. It deserves many readers among the Anglo-Saxon peoples, whose statesmen were closely associated with the establishment of the small republics of the south-east Baltic. As the author points out, it is not enough to sentimentalize over the fates of the small peoples of Europe in the grip of the great totalitarian powers: it is a question of learning as well as of feeling if there are to be any prospects of a better Europe.

Mr. Hampden Jackson has provided the most substantial book on Estonia which has yet appeared in the English language. He has the happy facility for handling solid material and considerable detail so that the result is very readable. There is a clear pattern of development running through the book which helps the reader considerably, and it is possible to absorb easily much information about the Estonian republic. The book is written from an historical and political standpoint, and on its historical and political method, rather than on its geographical interest it should be judged. Geographers might like to see included an account of the advantageous conditions for sea-faring on this part of the Baltic coast, which have such great political significance, but in spite of this omission they will find plenty to interest and inform them especially in the author's treatment of the economic fortunes of Estonia.

Historians might perhaps hesitate over the account of the Teutonic Knights' activities, and over that of the rule of their successors and descendants, the famous Balts. It is difficult to write with detachment of either group, since both to-day appear to Western Europeans as the prototypes of all that is most loathed in modern Germandom. Mr. Hampden Jackson has certainly felt tempted to let himself go on the subject. But there are other aspects of the *Ritterschaft* in the East Baltic which need remembrance. The Knights in the days of their greatest power (the thirteenth and fourteenth centuries) cruelly oppressed the Estonians; but it would not be difficult to find in Europe during these two centuries many examples of ferocious and persistent beastliness of conqueror to conquered and of lord to tenant and serf. The later Balt barons in the directness and brutality of their relationships with the Estonian peasants are repellent. But both Teutonic Knight and later Balt had something of the formidable competence which, as Professor Toynbee points out, makes the unpromising kingdom of the "legendary" Prussian "the 'education of Europe' in certain matters which no good European can afford to despise."

The three maps accompanying the book are clear, and the diagrams emphasize effectively the points discussed in the text. H. G. W.

THE WEST HIGHLANDS AND THE HEBRIDES: a geologist's guide for amateurs. By ALFRED HARKER. *Cambridge: University Press*, 1941. $8\frac{1}{2} \times 6$ *inches; xiv + 128 pages; drawings and sketch-maps.* 8*s* 6*d*

The many friends of the late Dr. Harker will welcome this book as a keepsake. Geologists, amateur and professional, whose fortune takes them to the Isles, will be fortunate if they have it in their pockets for it will lead them straight to classical spots. Geographers, and the layman with an inquiring mind, will find in it paragraphs which raise and answer questions to make a walk or a sail more

entertaining. To the student of metamorphism the frequent reference to this subject in the description of a particular section will let him collect what he wants and might not otherwise have easily located.

The book starts with Mr. Boys Smith's explanation of and apologia for its publication. This may serve to disarm critics who looked for something more philosophical and satisfying from the author's none too copious pen. A short biography by the late Sir Albert Seward is full of understanding and is an affectionate memorial to an honoured friend. There is also a preface by the Editor, Dr. J. E. Richey, well qualified to round off what Harker had not completed in a few chapters of the book.

Harker's works are all noteworthy for the skilful use he makes of line drawings. In this volume eighty-one profiles of the Scottish coast are given, all sketches made by the author on the spot, and annotated to show how the features reveal the rocks below or the extent of the raised beaches of the coasts. Maps I–IV, chosen from other sources, are satisfactory and necessary, but maps V–VIII are hardly an adequate portrayal of the west coast of Scotland in such a book.

The first chapter is an enviably stimulating review of the geology of Western Scotland from the pre-Cambrian to the Sub-Recent. No major feature is overlooked. His own view is stated with clear moderate rationalism although some of the controversies are mentioned. In such a land where comparatively little of the rock structures can be seen on account of peat and glacial debris, theories have sprung up and been indefatigably tended by imaginative people with no responsibilities. In this account they are judiciously restrained.

The remainder of the book is nearly all descriptive and shows surprisingly wide knowledge of details of the coasts and remoter islands of the West of Scotland from the Clyde to Cape Wrath. There are few spots between these limits where the visitor will not be able to find guidance to geological highlights from the book. Especially is this true of Skye, that will always be associated with the name and fame of Alfred Harker. J. V. H.

ASIA

FIVE MILES HIGH. Edited by ROBERT H. BATES. *London: Robert Hale*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 320 pages; illustrations and end-paper sketch-maps.* 15*s*

This book is a narrative of the first American expedition to K2, the highest summit in the Karakoram range, during which two of the party reached the height of 26,000 feet, or little more than 2000 feet below the summit. All members of the party were trained mountaineers, some of whom already had experience of Himalayan conditions. The mountain was closely explored thirty years earlier by the Duke of the Abruzzi's party, which contained certain well-known Alpine guides, and an attempt was then made to ascend the peak from the south. The American party at first rejected this route, hoping to find a better approach from the west. This however proved impracticable for porters owing to a steep ice wall, and after exploring further the eastern approaches the Americans decided to follow in the footsteps of the Duke's party. Two main obstacles stood in their way: the steepness and presumed difficulty of the Abruzzi ridge (one of several ill-defined buttresses), and the doubt whether suitable sites could be found for the higher camps. It is greatly to the credit of the 1938 party that not merely did they solve both these difficulties by brilliant endeavour but also ensured that their line of supply from the base remained always open. Such care in organization and safeguarding the health and lives of the native porters brought the advance party to the snow shoulder at the foot of

the final peak. Even if further success was denied, the expedition had shown the way for future attempts on this, the second highest mountain in the world; good staff work, and a balanced outlook on what risks were justifiable, kept the party free from casualties, and thus the whole expedition is in marked contrast to the disastrous sequel of 1939.

The narrative is well arranged and distributed among the participants mainly to accord with the leading part played by each man. Consequently in every chapter the record is given from individual experience; and though one might expect some break in continuity, in fact the narrative gains in harmony through this distribution of labour. The book is written in a fresh and vivid style, and enlivened by pencil drawings in addition to photographs. In reproduction, some of the wider views have been unduly reduced in size, thus losing the impression of great height. There is one serious gap in the illustrations: no photograph is given to show the exact route taken by the party in following the Abruzzi ridge.

As a model of a carefully planned and prudently executed attempt, this expedition is worthy of the closest study by all who, in better days, may contemplate a renewed attack on the giants of the Himalaya. H. E. G. T.

INDIAN HARVEST. By PAMELA HINKSON. *London: Collins*, 1941. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 320 pages; illustrations.* 16*s*

Serious students of Indian Affairs may gain little fresh knowledge from Miss Hinkson's book, and yet may read with pleasure her vivid record of the impact on an open and eager mind of first-hand contact with the country and a great variety of types from Viceroy, residents, landowners, and Rajahs to missionaries, peasants, and artisans. 'Indian harvest' should be particularly instructive for those who seem to believe, as ingenuously and unimaginatively as she before her travels, that India is one country with one speech, one mind, and one ambition, and that all problems would instantaneously be solved if only an obstinate Indian Government would "give India freedom."

Determined to meet people and see life, rather than to inspect architecture and ancient monuments, Miss Hinkson packed more varied observation and human experience into her seven months than many less intelligent travellers into as many years. Though her wanderings were confined to North and North-West India and her human contacts limited by ignorance of any native language, she acquired considerable understanding of linguistic, religious, social, racial, and economic problems, and vigorously conveys in her pleasant wholesome book some idea of their complexity to the uninformed reader. E. O. L.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE in the North Atlantic Ocean, Season 1939. By W. P. HAWLEY and F. M. SOULE. U.S. Treasury Department; Coast Guard. Bull. No. 29. 9×6 *inches; 134 pages; charts, diagrams, and tables*

The desirability of patrolling the ice region in the vicinity of the Grand Banks of Newfoundland during spring and early summer when the transatlantic steamship lanes are threatened by drifting ice was considered at an International Conference on the Safety of Life at Sea, held in London in November 1913. A convention was signed by representatives of the various maritime powers during the next few months, and the good will of the United States Government made it possible for the service to begin at once; the U.S. coastguard maintains the patrol and each nation bears a proportion of the cost.

The patrol is concerned mainly with the area between latitudes 39° and 49° N.

and 43° and 56° W.; two coastguard cutters work alternately, relieving each other every fortnight, and a third vessel, the *General Greene*, works independently, making the oceanographical observations that are the foundation of the current charts used by the ice observation officer. The cutters endeavour to collect information from every ship in the neighbourhood, and search the most important parts of the area themselves; when the weather is clear they steam at 15 knots, and generally follow some particular menace when there is fog. A summary of the ice conditions is broadcast four times a day, and ships are either warned if they are standing into danger or special inquiries answered. The steamship lanes used by the principal shipping companies are the first consideration, and since the patrol began no lives have been lost through vessels striking ice.

Bulletins are issued at the end of every season and also when special results are available. In 1939 the ice season began early and developed into one of the heaviest that the patrol has encountered: the first bergs approached the area in February and the most southerly drift occurred between May 28 and June 3, when ice was reported near 40° N., and vessels were recommended to use an emergency lane 60 miles south of the usual most southerly route. The Canadian tracks were obstructed with field-ice till May 16 and the Strait of Belle Isle north of Newfoundland was open after June 15. The last berg in the patrol area —of rounded shape such as would not calve readily, and must therefore melt slowly—disintegrated to such an extent that it was no longer a danger to navigation on August 22.

The *General Greene* carried out four surveys making vertical series of temperature and salinity observations along three lines across the principal water movements; the data were used to prepare charts showing the topography of the pressure surfaces in the sea, somewhat similar to the familiar isobaric charts incorporated in weather maps, and usually known as charts of dynamic topography. The ice patrol finds that bergs generally follow the contours of the chart, the agreement being good enough to afford them great assistance in tracing and following reported dangers. The agreement is better than many oceanographers would expect because the use of the contours of the topographic chart as current lines minimizes the effect of vertical water movements, wind, radiation, and friction, and it seems that the bergs, which reach to a depth about five times their height, also average or minimize these effects; the fact that bergs and field-ice do not necessarily follow the same paths has a bearing on the question. Another method which the patrol uses to follow water movements is comparable to the isentropic analysis lately adopted by meteorologists, though in the ocean it means following the distribution of some characteristic property along a surface of uniform density instead of along a surface of uniform entropy.

One of the conclusions reached in 1939 was that the increase in the amount of drifting ice compared with other years was due to the Labrador Current being driven farther offshore by an abnormal prevalence of strong west winds during the previous winter; the result of such a displacement was that fewer bergs grounded in shallow water and the ice which took the deeper path melted more slowly in the colder water.

Most of the bergs drift southwards towards the "Tail" or southern extremity of the Newfoundland Banks, and then curve away to the east and north-east to melt in the warmer water. The water movements are however very complex in the southern and eastern parts of the area; the Gulf Stream is undergoing a great change and more and more water eddies from its northern flank to form a complicated and variable pattern of streams and isolated patches with the cold

water of the Labrador Current. The fog which would be expected to be prevalent in such a region is often a hindrance to the patrol; a cold front with a strong force of polar air behind it will keep the area clear, but if the fronts are dissipated early, as often happens with the approach of summer, moist tropical air flows northwards and the resulting fog has been known to last as long as thirteen days. The Bulletin states that a cooling of the tropical air by only 2° F. will produce fog, and shows how the fog-wall may be coincident with the boundary of the cold and warm waters.

Reports of ice off the Labrador coast and notes on glacier discharges from Upernavik and Jakobshavn were collected for use during the following season, and when the patrol area was free from ice the *General Greene* made a cruise across the Davis Strait to make routine measurements on the early part of the Labrador Current and the West Greenland Current.

The Bulletin includes an interesting collection of monthly ice and temperature charts, and a long list of all the ice reported; other floating objects are occasionally noted, drifting buoys, a derelict, and a drifting dory. All the oceanographical data are also listed. The Bulletin is compiled and written by Lieutenant W. P. Hawley, Ice Observation Officer, and F. M. Soule, Senior Physical Oceanographer. G. E. R. D.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE VOYAGES OF SIR JAMES LANCASTER TO BRAZIL AND THE EAST INDIES 1591–1603. New edition with Introduction and Notes by Sir WILLIAM FOSTER. *London: printed for the Hakluyt Society*, 1940. *Second Series No.* 85. 9×6 *inches;* xl+178 *pages; illustrations and maps. To members* 21*s*

The importance of Lancaster's voyages, as the pioneer English efforts to open up direct trade with the East by the Cape route, needs no stressing, and the President of the Hakluyt Society has done good service by bringing together, in its latest issue, all the original documents relating to them, some hitherto little known. The accounts of Hakluyt and Purchas were reprinted by Sir Clements Markham for the same Society in 1877, in a volume long out of print, but much new information has since accumulated. The additional matter in the present volume consists chiefly of three contemporary printed pamphlets, now excessively rare. The largest, written by Henry Roberts, relating to Lancaster's raid on Pernambuco in 1594–95, is known only from copies preserved in two American collections, that in the John Carter Brown Library being here reprinted with the courteous aid of its Librarian. It is evidently based on the same original source, now lost, as Hakluyt's version, but adds some useful details, though not to be trusted implicitly where inconsistent with Hakluyt's account. The other two documents, both preserved in the Bodleian, refer to Lancaster's third voyage, that to the East in 1601–03: actually the first venture of the East India Company, which had not yet taken formal shape at the time of Raymond and Lancaster's pioneer voyage of 1591–94.

It is hardly necessary to say that the volume displays the scholarly outlook and full knowledge to be expected from one whose work as Historiographer to the India Office is known to all students and who had already edited five important volumes for the same society. The introduction sums up with judicious brevity the outstanding facts relating to the voyages, and also brings together the all too scanty details of Lancaster's life and character yielded by careful research. The latter is shown in a pleasing light. Quiet efficiency is held to have been his outstanding characteristic: his plans were laid with care

and carried out with resolution, while he was ready to take risks on occasion. On the other hand his personal modesty is hardly less striking.

Sir William's explanatory notes are wisely kept within moderate limits, but give just the information needed for the proper understanding of the occurrences. A striking portrait of Lancaster, reproduced from one owned by the Skinner's Company (of which Lancaster was a member and benefactor), is given as a frontispiece, and there are some useful outline maps together with the reproduction of an old print depicting a sea fight in which Lancaster took part.

E. H.

GENERAL

THE YACHTMASTER'S GUIDE AND COASTER'S COMPANION. By FRANK G. G. CARR. *London: Peter Davies*, 1940. 10×7½ *inches;* xvi+467 *pages; charts and diagrams.* 25*s*

When the Board of Trade, at the request of the Admiralty, introduced the Yachtmasters' Coastal Ticket there was no book which covered the syllabus. This want has now been filled in this ample, well-produced, and original book. It is ample because it covers not only the Board of Trade extensive syllabus, but a great deal more useful knowledge, and it is original because the author has not followed the rather dreary style of previous text-books but struck out with his own methods of teaching.

He begins with the very tiresome subject of magnetism and by starting with the history of the compass contrives to make it interesting and easily understood. As this is a subject on which the Board of Trade are very particular, it is gone into most fully with many diagrams of the different sorts of magnetic influences to be found, the ways of correcting the compass, and a special chapter on amplitudes and azimuths. Next comes a section on Chartwork: this begins with the construction of the chart, goes on to all the practical problems to be solved on the chart, and then gives a most lucid description of tides. Included here are two very good reproductions of Admiralty charts with all the problems marked on them. The third section deals entirely with Meteorology. Here we have a full description of all the instruments needed and how to use them, and a very clear exposition of the atmosphere with all its combinations. There is a good explanation of the Front theory of weather and the section ends with a useful chapter on the Law of Storms.

Following these three sections, which cover the written papers of the examination, come those dealing with the oral part. Joseph Conrad has well described the nature of this inquisition, which in his case lasted four hours, and his examiner kept putting his imaginary ship into worse and worse situations until finally with her anchors gone and her masts cut away she was driving on to a lee shore. "There is no more I could do," replied Conrad. "You could at least say your prayers," was the examiner's reply. Here the author has made some very original innovations. The first chapter dealing with the Rule of the Road is illustrated with many drawings coloured with red and green lights and little sketches of ships, trawlers, tugs, and pilot cutters all pursuing their lawful occasions, sounding their sirens and clanging their bells. It is a very good way of helping the memory over this confusing set of laws on which the Board of Trade are apt to be somewhat pedantic.

The final part of the book is devoted to seamanship. After a general chapter on rope and its uses, the appliances used by seamen, and the sextant and chronometer, the whole subject of seamanship and its application is dealt with in the form of question and answer. There are some hundreds of questions

with the answers to almost every conceivable circumstance which could arise in a ship whether sail or steam, at anchor or under way, and the correct solution is given to all the problems arising out of accidents at sea.

Appendices contain many other things the syllabus for the examination requires, such as models of vernier scales and compass cards, and finally a complete set of practice papers with their answers. Specimen pages from the Nautical Almanac and azimuth tables are included which makes this work complete in itself. Any one who wishes to delve into the mysteries of the seaman's art should have this book.

As the author says in his preface, he has not written the book for the examination candidate alone. His object has also been to write a handbook of yacht handling and fore-and-aft seamanship. This he has most aptly done. His chapters are headed with delightful quotations, of which some are:

"These vulgare marine Charters dilineate with Parallele meridianes and right lined Rumby." Digges.

"On an ideal earth completely surrounded by water." Admiralty Manual of Navigation, 1914.

"When two Englishmen meet their first discourse is of the weather." Samuel Johnson.

"Change of weather is the discourse of fools." John Ray.

"That subtile Body that immediately incompasses the Earth, and is filled with all manner of exhalations, and from thence commonly known by the name of the Atmosphere." Plot.

"Some are weatherwise, some are other-wise." Benjamin Franklin.

"As the devil said to Noah 'It's bound to clear up.' " Proverbial saying.

"Thirdly the stredge may be so disorderly handled as that thereby the Pylote may be abused." John Davis. A. C.

THE MONTHLY RECORD

SCHOLARSHIPS IN GEOGRAPHY AT OXFORD

The War has emphasized the value of Geography as a subject in education and its importance is being realized increasingly in the University of Oxford, where the Colleges are making more provision for the award of Scholarships and Exhibitions in the subject. We are informed by the Professor of Geography in the University that Hertford College will again award a scholarship of the maximum value of £80, on a joint examination with Jesus College, which will also offer awards. At their joint examination for entrance scholarships in Modern Subjects, University and Balliol Colleges, New College, Magdalen, and Corpus Christi Colleges will require that each candidate shall take two general papers and offer two subjects, of which one may be chosen from Modern History, English Literature, a modern language, Latin and Greek, or two out of seven alternatives in specified Natural Sciences: the other may be Geography alone, with one paper on Physical Geography (Land Forms and Climate) and another on Human and General Regional Geography (including the elements of Political and Economic Geography).

This schedule of subjects for entrance scholarships on the modern side must do a great deal to give Geography a better place in the instruction of the higher forms at school, but does not seem to encourage the desirable alliance of our subject with mathematics.

CAPTAIN ANTHONY TROYER AND THE SURVEY OF INDIA

When engaged many years ago in preparing a critical edition of the Sanskrit chronicle, Kalhana's 'River of Kings,' Sir Aurel Stein became interested in the life and work of a predecessor in this field, Captain Anthony Troyer. Troyer was known to have assisted in training surveyors in India during the early years of last century, but the importance of his work was only established by the researches of Colonel R. H. Phillimore into the history of the Survey of India. To the information supplied by Colonel Phillimore, Sir Aurel has added data from the archives of the India Office, furnished by Sir William Foster, and of the Austrian War Office, and is thus able to give for the first time a connected and detailed account of Troyer's work, in the *Journal* of the Royal Asiatic Society of Bengal (6 (1940) 45–59).

Anthony Troyer von Aufkirchen was born at Klattau in 1775, and after passing through the Military Academy at Wiener-Neustadt, was gazetted to the 38th Infantry Regiment in 1791. After serving with much distinction he was promoted to the Q.M.G.'s department, and in 1798 was sent to Italy as a surveyor. While there an event decisive for his future took place, his meeting with Lord William Bentinck, probably at the siege of Genoa, for three years later Bentinck, who had been appointed Governor of the Madras Presidency, invited Troyer to accompany him to India. Troyer accepted readily, left the Austrian service, and received a commission as ensign in the 12th Foot. Bentinck had no doubt been attracted by Troyer's general ability, and possibly by the interest in Oriental languages which he was already showing, but it is also significant that within a year of their arrival in India Bentinck should have secured his appointment as an instructor in surveying. In 1804 the Commander-in-Chief at Madras urged the advantage of having the recently conquered territory adequately mapped: the Governor immediately approved of the proposal, and ordered the establishment of a class for the special training of a number of cadets in topographical survey. To this class, which developed into the Madras Military Institution, Troyer was appointed instructor. For the

eleven years of its existence Troyer was entirely responsible for its conduct and for the training of many surveyors who markedly influenced the technique of topographical surveying later adopted by the Survey of India.

The principal feature of Troyer's work was the introduction of the plane-table as a standard instrument of survey. This was in use in Europe, and Troyer had no doubt employed it in Italy, but up to this time mapping in India had been based mainly on military route surveys. It is noteworthy that the "plan of instruction" drawn up by the Governor included from the start "the practical part of surveying with the plane-table." There is no indication in Sir Aurel's article however that the method of resection, by triangle of error, which one has always been taught was developed in the Survey of India, and was later the essential point in the extended use of the plane-table, was introduced by Troyer. Each course at the Institute lasted two and a half years, and under Troyer's supervision an average of 1620 square miles was surveyed annually. The work was based on the triangulated points of the Great Trigonometrical Survey, which had been begun by Lambton near Madras in 1802, minor triangulation being carried out by Troyer or the more senior pupils. The work was done on a scale of 4 inches to 1 mile, and the plane-table sections were laid out on a continuous rectangular grid.

For reasons of economy, the Military Institution was abolished by the East India Company in 1816, despite the protests of the Commander-in-Chief at Madras, who wrote of "the great mass of geographical and topographical materials with which . . . the students of the Madras Institution have enriched the records of the Company and in some instances of the civilized world." Though Troyer's work was thus brought prematurely to an end, his influence continued. Colonel Phillimore sums up his work thus: "The methods taught by him gradually extended to the Bengal Presidency as Madras trained officers were eventually brought up to Bengal. . . . Holding the post of Instructor for eleven years he trained a large number of officers in this system which in its main principles has persisted to this very day."

Placed on half-pay, Troyer returned to Paris in 1817, where he continued his oriental studies. Ten years later he was again invited by Bentinck to accompany him when he returned to Bengal as Governor-General. This time however Troyer employed himself entirely with linguistic studies, serving as secretary to the Government Sanskrit College at Calcutta until he finally left India in 1835. He was described as a man wholly indifferent to fame and content to satisfy his interest in study for its own sake, and apart from the publication of his edition of the 'River of Kings,' his later years were uneventful. No doubt this trait explains his reticence regarding his early work in Madras, which prevented its true value from being appreciated until recently.

THE LONG RANGE DESERT GROUP IN LIBYA AND FEZZAN

The *Egyptian Gazette* for 14 February 1941 contains a fuller though still discretely vague account of the story which appeared in one form or another in London papers of the same date: the exploits in the Libyan desert of motor patrols commanded by three officers, described as a retired Major of Signals, an archaeologist serving until war broke out with the Palestine Government, and a former well-known member of the Egyptian Survey. It was not hard to identify them as Major (now Colonel) Bagnold, Mr. W. B. K. Shaw, and Mr. P. A. Clayton, all well known to the Society as great exponents of the art of travel in the Libyan desert. The section on Motors in 'Hints to travellers,' vol. II, begins: "The justly condemned performance of those who take a pride in making cars go on journeys in which the whole attention must be con-

centrated on getting the car through, and it is a mere impediment, should not obscure the fact that in certain countries, notably the Libyan Desert, the careful use of cars has extended the possibilities of travel, and journeys have been made which could not have been carried through by any other means. . . . The most complete account of how to adapt a car for long-distance travel in waterless desert is found in papers in the *Geographical Journal* by Major Bagnold"; and in the following nine pages the fruits of his long experience are preserved. It is well worth while to read them again now, for better understanding the story of the L.R.D.G., which could claim that between September and the end of the year its patrols had covered half a million truck-miles without losing a single car.

Navigating, it would seem, with sun compass by day, and tying to star positions by night, the patrols surprised Italian posts from Aujila to Uweinat, and later moved *via* Tibesti into Fezzan, where they burned the fort and the hangars at Murzuk and captured the town of Traghen.

The Cairo illustrated paper *Parade* of March 8 has some pictures from the Group, and in its account some interesting details. In stony desert they could identify the light car tracks of the 1914–18 war and the Citroen caterpillar tracks of Prince Kemal ed Din in 1925. The steel plates described by Bagnold in 'Hints' are now the standard equipment for "unsticking" cars sunk in liquid sand. The radiator condensers are so efficient that they spend only 2 pints of water in 3000 miles. The navigator avoided wells and inhabited posts so well that when the force arrived within sight of Murzuk the guard was in misapprehension turned out not to repel but to salute them. We shall hope to hear more details of this navigation when at some future Meeting the commanding officer of the L.R.D.G. can read another and more exciting paper on Journeys in the Libyan desert

WIND FORCE AND EXCEPTIONAL VISIBILITY AT SEA

In the Admiralty Weather Manual it is stated that "At inland stations visibility improves with increasing wind speed and winds above 20 knots are rarely accompanied by poor visibility. At coast stations and in the open sea however the higher winds raise quantities of spray which diminishes the visibility near the surface." The first statement needs qualification for deserts. Mr. I. R. Tannehill, in the *Monthly Weather Review* for August 1940, has attempted to give statistical proof of the general statement on the relation of wind velocity and visibility at sea.

Observations have been made by the Marine Division of the U.S. Weather Bureau for many parts of the ocean; Mr. Tannehill has chosen an area in the Pacific, 0–15° N. and 125–170° W., where there are 19,261 observations, for detailed analysis. For simplicity of work this area was divided into 5° squares and in each the entries of exceptional visibility "V" counted for each value of the Beaufort scale of wind force. The figures obtained from all squares were added together and a graph constructed, percentage frequency of "V" being plotted against wind force. It was found that the percentage of "V" increased from calm to force 2 and decreased from 3 to 7, after which the significance is doubtful because of the infrequency of readings. It is however known that at hurricane forces 11 and 12 the air becomes so filled with spray driven from the sea that there is no visibility for any distance.

The area chosen for detailed work was suitable for giving a general conclusion; there is a relatively high average wind velocity, absence of fog, and distance from continental areas. Other graphs showing "V" plotted against wind velocity in knots off the coast of West Africa show that the general conclusion probably holds good for most parts of the ocean.

GENERAL CARTOGRAPHY

In his book on 'General cartography,' reviewed in the *Journal* for November last Mr. Erwin Raisz dealt at length with statistical maps and cartograms, and we have now received from him a reprint from *Mining and metallurgy*, March 1941, entitled "Geographical distribution of the mineral industry of the United States," and described as an application of the Block-Pile System to statistical maps, the first large-scale application of the method. There are six plates of which we may take Nos. 1 and 2 as simpler examples. Plate 1 is a series of diagrams showing the value of minerals in their first marketable form. Each 10 million dollars' worth of gold, for example, is represented by a column $10 \times 1 \times 1$, and the value of gold being 178 million dollars, the block-pile consists of three rows of five columns and a fourth row of two columns and a shorter one representing the odd 8 million dollars. In the simpler cases where the block-pile refers to one product the representation is sufficiently intelligible, though for greater security the author prints underneath the figures which the block-pile represents. When a number of products are included in one pile which is dissected by horizontal planes to represent the contributions of the several components, representation is less good, because to form an estimate of the value of each component, one has to imagine the depth of the relative layer multiplied by twenty and taken into a column. A further complication is caused when, as for bituminous coal, the heights of the columns are varied so that they stand in rows representing the production for each month of the year, and the volume of a column in each row, having a curved top, is not easy to estimate. When the block of vertical columns is cut into at the side to represent the varying production, it appears to us that estimates are even more difficult. The essential facts are in the figures printed under each diagram. The block-pile is an alternative notation to these figures, and opinions may well differ whether its advantage to what they call a photographic brain is sufficient to compensate for the space and labour that this method of representation entails.

Plate 2 is a representation on an outline map of the United States of the production of crude petroleum, natural gasoline, and natural gas in 1938. The graphic representation is by cylinders or tanks, not square columns, and the distinction between tanks of petroleum, gasoline, and natural gas is made by difference of shading. The figure as a whole shows how much the production of these products is concentrated in the Kansas and Texas area and on the Pacific coast about Los Angeles. The distinction between the columns representing the three products does not seem sufficiently clear, and one doubts if the most photographic brain could retain the variegated picture in memory. But the placing of the block-piles on the map gives, one may admit, a graphic picture of the broad facts of how production is distributed, though at considerable expense of space and time. This representation of simpler facts is at any rate graphical. In looking at the remaining plates one may be excused for thinking that the graphical effect has been confused or destroyed by the necessity for labelling the different parts of each block with the names or initials of the various metals and non-metallic minerals.

The students of these cartographic devices will find in this paper much to ponder and will be able to make up his mind whether it is better to maintain the same vertical scale for a million dollars, or to vary it from plate to plate; whether it is better to label the block-piles with place-names and numbers, or whether one should concentrate on the graphic representation and leave the place-names at any rate to be sought elsewhere.

Apart from these disputable questions of how far to go with the use of block-pile diagrams, there is an immense amount of curious and interesting

information in this paper, where one sees that the gold import of Great Britain to the United States in 1938 was approximately equal to the world production of the metal; and that Canada and the U.S.S.R. ran close as the leading producers of platinum, whereas two-thirds of the import of the metal into the United States came from Great Britain. One learns also that the natural gas gathered in 1938 was valued at 111 million dollars at the wells, but sold for over 500 million dollars at the other end of the pipe-lines. When production is shown in tons and imports valued in dollars it would be useful to have some figure for the value per ton.

Accompanying the paper is a physiographic map of the land forms of the United States by Mr. Raisz. The reproduction is on so small a scale that one cannot properly estimate the beauty and interest of the original, of which we received a full-sized copy from the author some weeks ago, which will be the subject of a separate note.

PROBLEMS OF MODERN EUROPE

J. Hampden Jackson and Kerry Lee have compiled an interesting commentary upon current affairs in Europe. (*Cambridge University Press*, 8*s* 6*d*.) Believing that text-books have failed to provide an easily intelligible introduction to politics and economics the authors have attempted to illustrate the various problems by using numerous maps and diagrams. The subject is divided into four sections: the basic problems, including standards of living, resources, etc.; the economy of the nations; attempts to achieve security, and, finally, problems for the peace conference. Statistical information is given by proportionately sized squares enclosing an appropriate symbol. Where these merely express percentages of a world total, they are not very informative, and in later diagrams the authors have added the corresponding figures. It is unfortunate that on an early diagram, showing the contrast between east and west Europe, the authors should have put the acres of farmland and number of cattle per head in west Europe at ten times their correct value, thus hiding the point they are endeavouring to make. However it is fair to say that this appears to be the only serious slip in the book. Occasionally the diagram does not support the statements in the text: certainly from that on page 19 one would not conclude, as stated in the text, that Hungary and Bulgaria were rich in foodstuffs. Apart from the merits of the method employed, the book is obviously a sincere and painstaking attempt to indicate impartially the causes of the present state of Europe.

THE OUSE FLOOD PROBLEM

Mr. W. E. Doran has drawn our attention to errors in the report of his reply to the discussion following his paper on the Ouse flood problem published in the April *Journal*. On page 234, line 22, Scurtchley should be Skertchley: the sentence beginning in the second line of page 235, should read, "As to the barrage excluding tidal water, that brings back the proposal made by some engineers, Messrs Crocker and Stevenson, at the enquiry held at King's Lynn in 1918," and the last sentence in the next paragraph "It holds back the tide until the level downstream has dropped."

MEETINGS: SESSION 1940–41

Twenty-fourth Meeting, 5 May 1941. The President in the Chair

Elections: Gordon Frank Baker; Miss Lilian Bates

Paper: Some aspects of Japan. By Mr. E. H. de Bunsen

Twenty-fifth Meeting, 12 May 1941. Major-General M. N. MacLeod, Vice-President, in the Chair

Paper: Map projections and sun compasses. By Colonel Sir Charles Arden-Close, Mr. F. S. Richards, Dr. J. R. Baker, Mr. A. R. Hinks

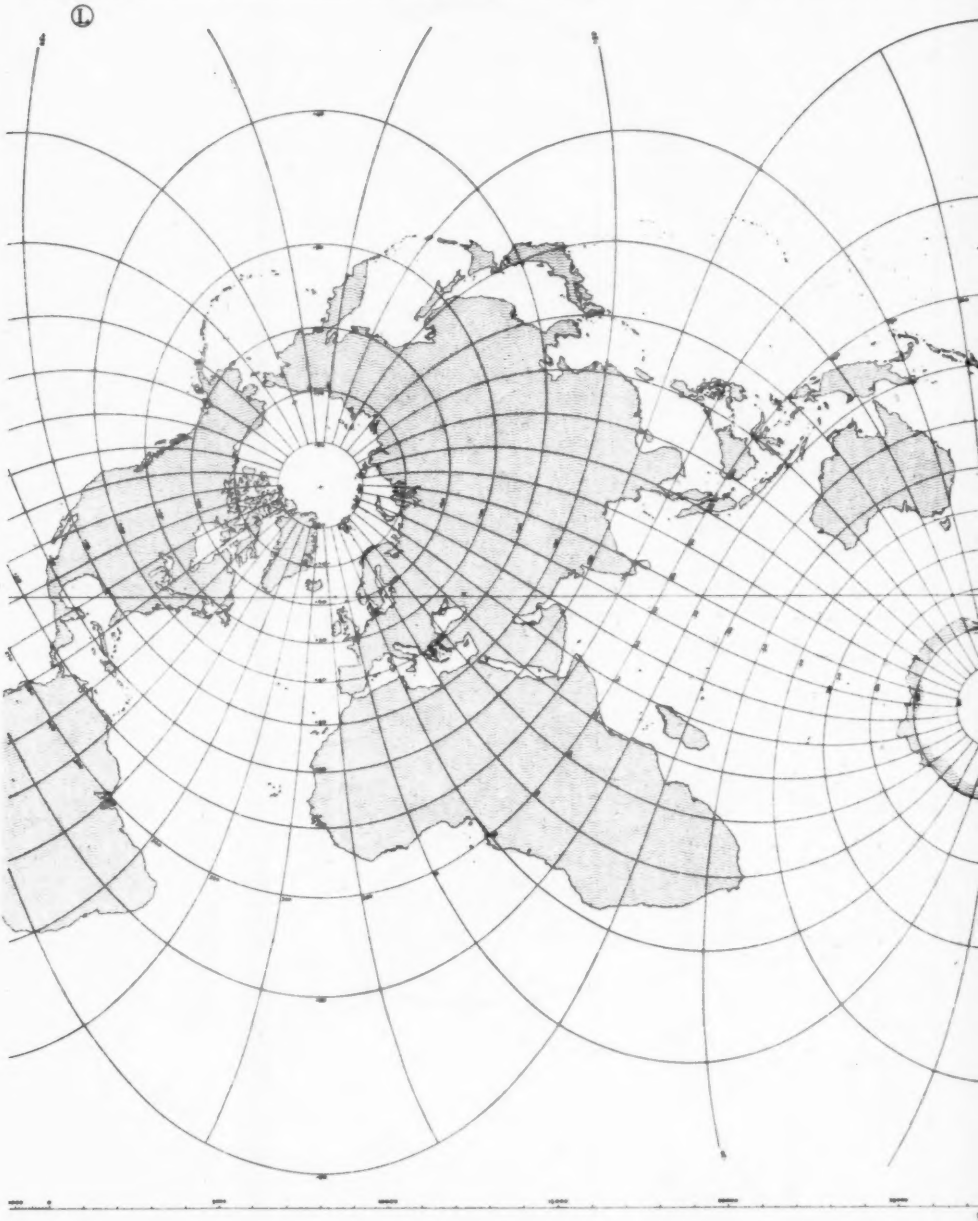
Twenty-sixth Meeting, 19 May 1941. The President in the Chair

Elections: Charles Alfred Fisher; Francis John Monkhouse, M.A.; Miss C. M. Paine; William Alexander Reeve Robertson

Paper: Highlands of Central Ethiopia. By Dr. Hugh Scott

Twenty-seventh Meeting, 26 May 1941. Colour and sound films of India by the Lawrence Thaw Expedition, and of Burma by Mr. Nathan

Map I. Pole +18° 105° E.



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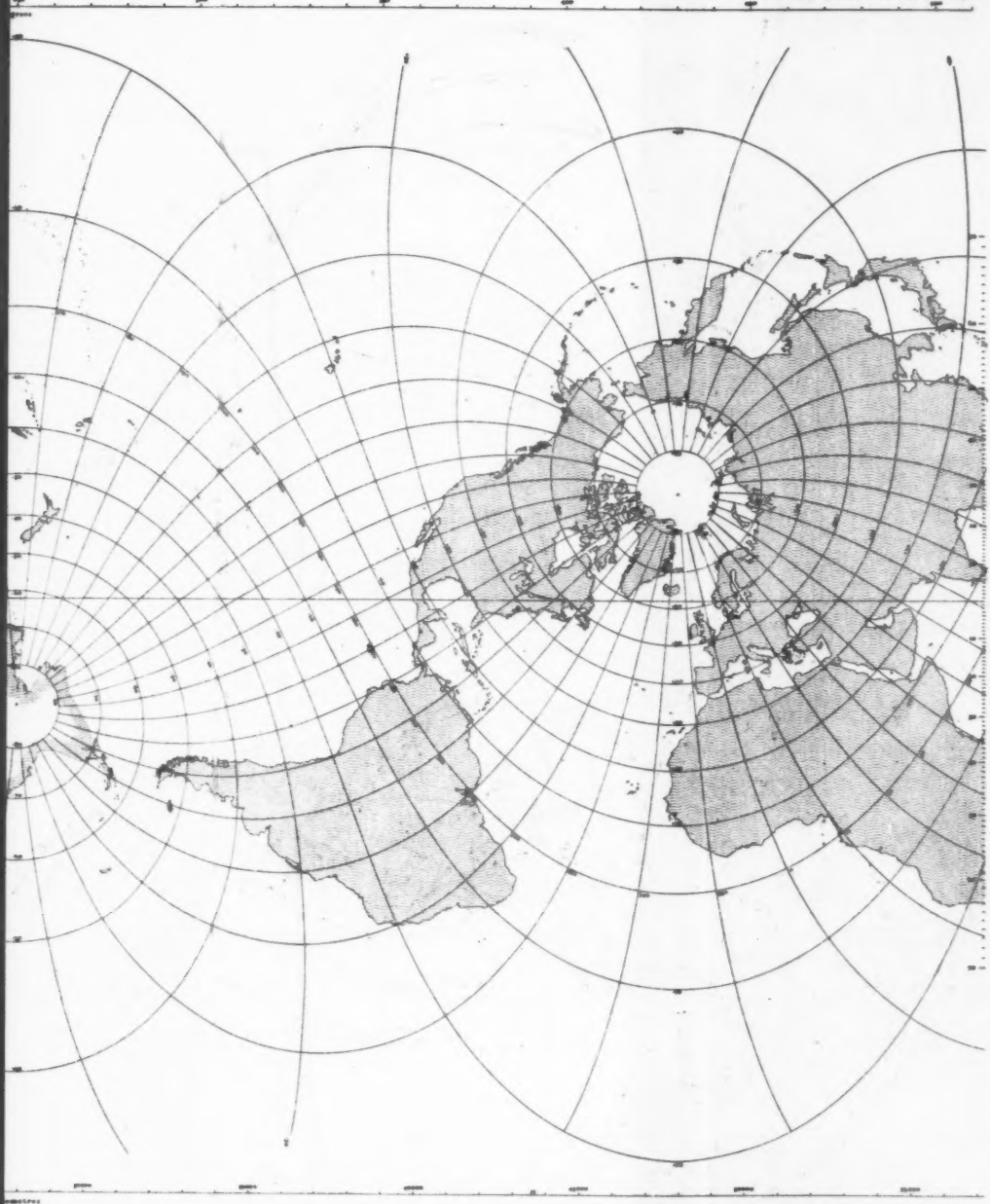

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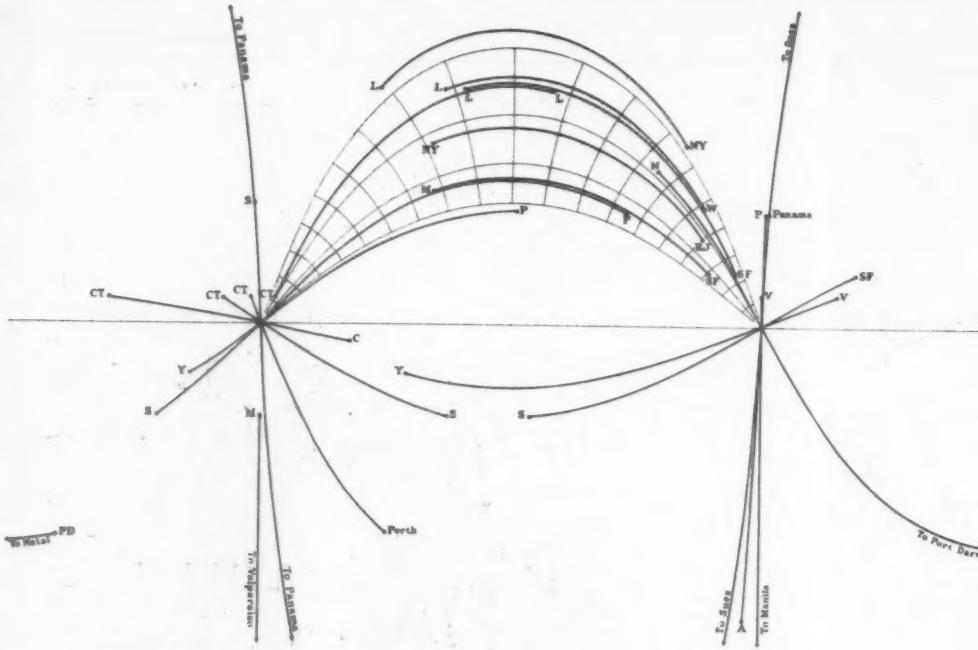
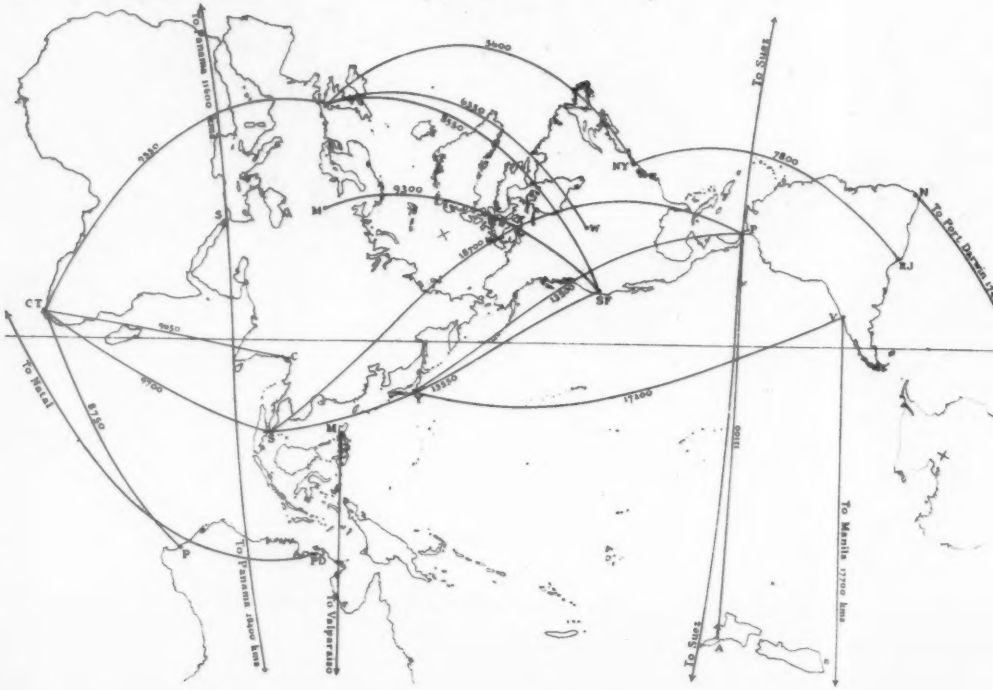
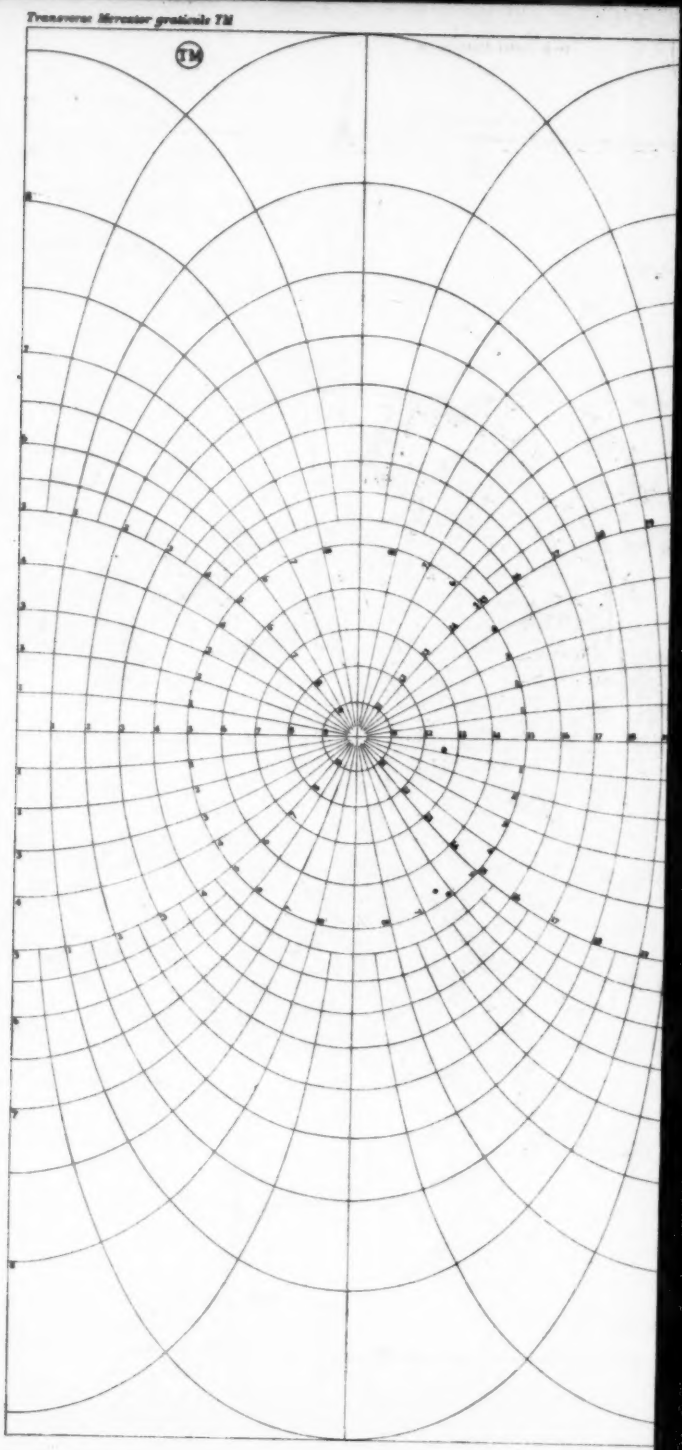
Oblique Mercator Projections
Hinks

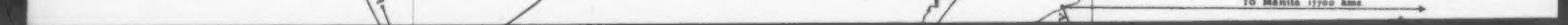
Great Circles drawn on TM

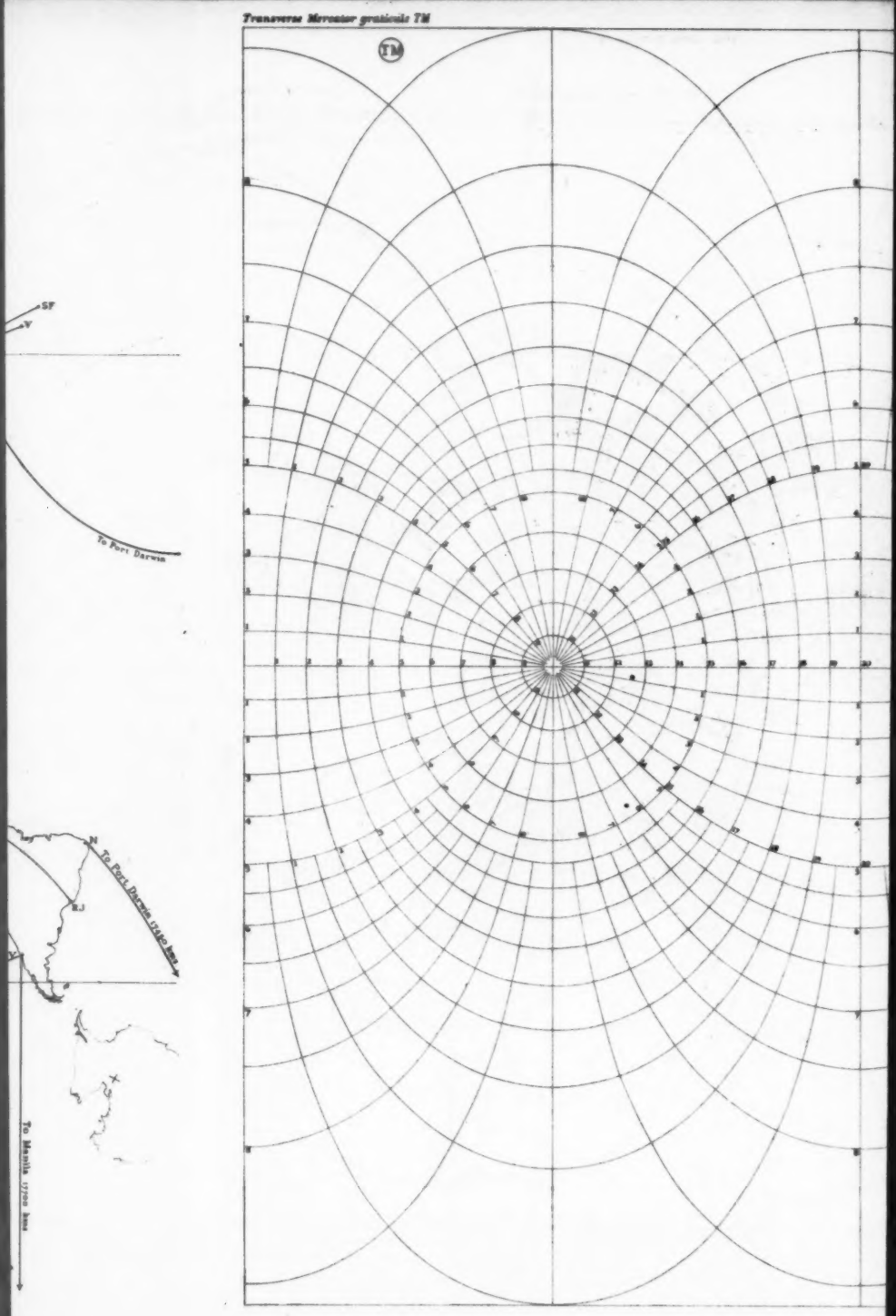


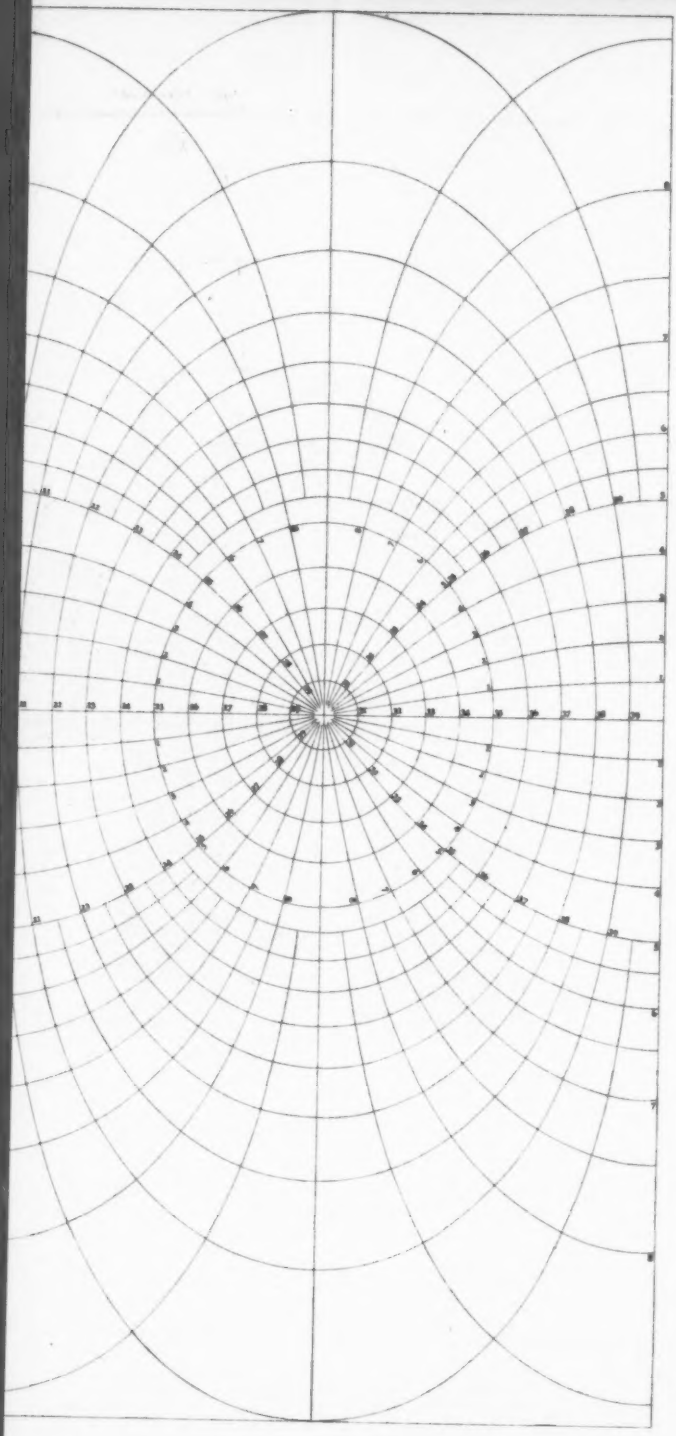
Great Circles from TM on Map D




Transverse Mercator graticule TM
TM


TO MANILA 1770 KMS

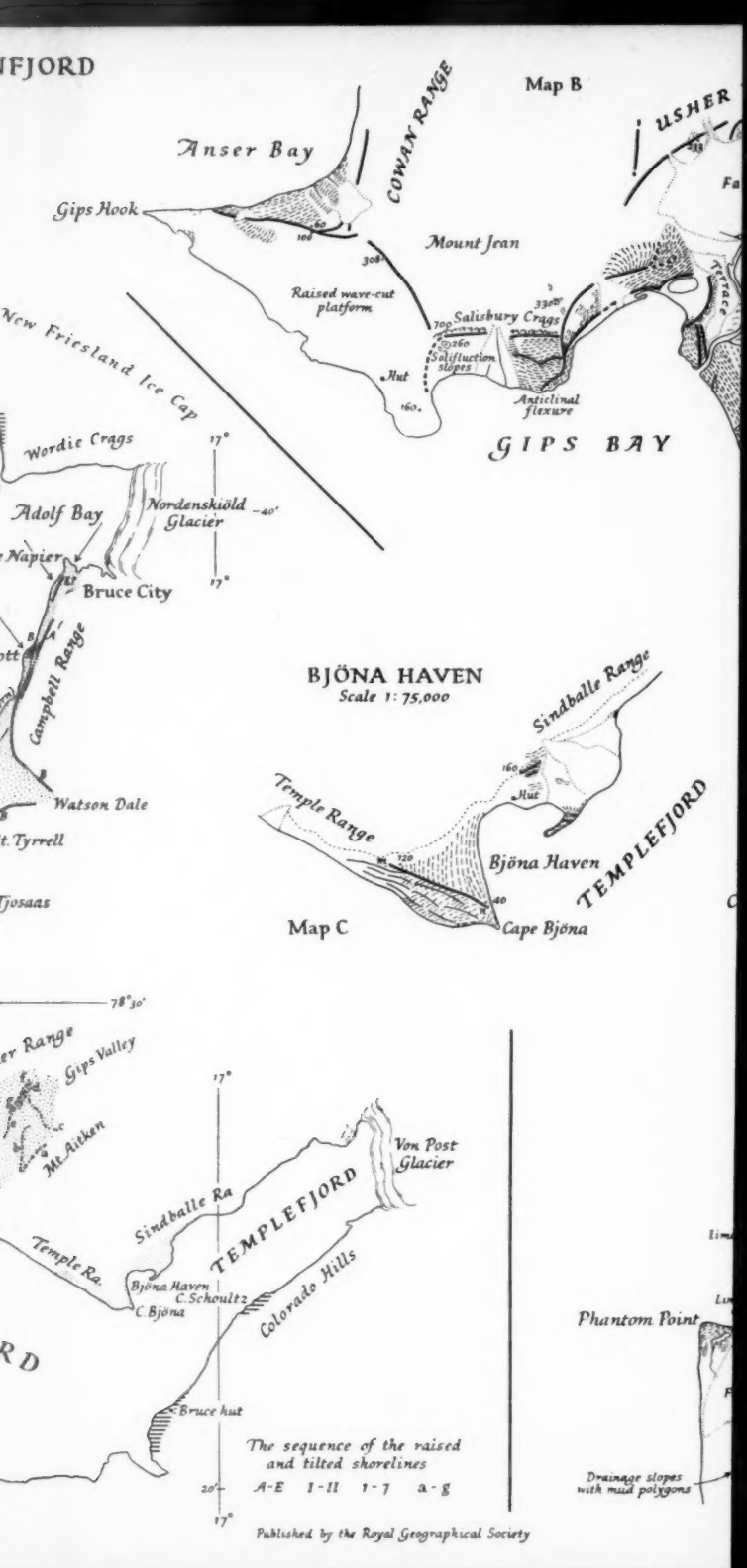

Transverse Mercator graticule TM
TM
SF
V
To Port Darwin
To Port Darwin (1540 kms)
To Manila (1700 kms)

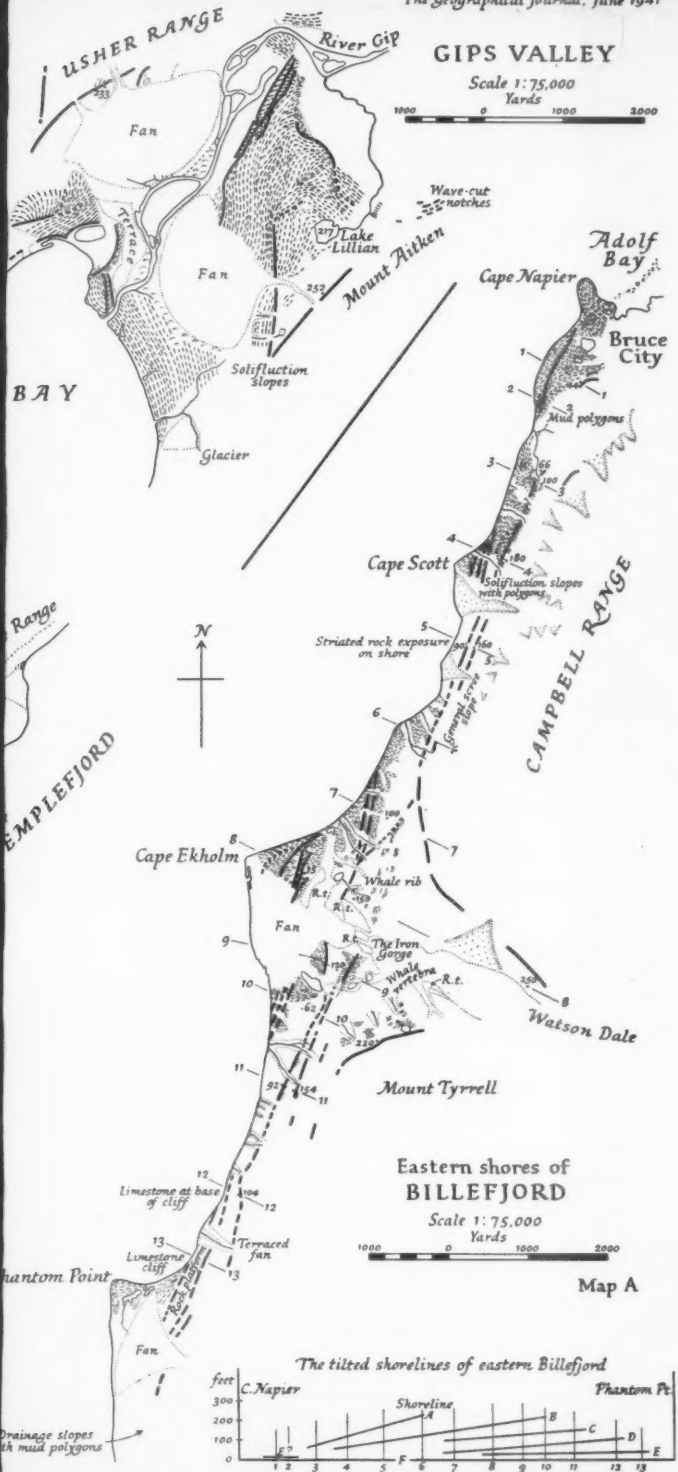


BILLEFJORD AND SASSENFJO
SPITSBERGEN

by W.G.V. Balchin

Fig.1


NFJORD
Map B
Anser Bay
COWAN RANGE
USHER
Gips Hook
Mount Jean
Raised wave-cut platform
Salisbury Crags
Solifluction slopes
Hut
Anticlinal flexure
GIPS BAY
New Friesland Ice Cap
Wordie Crags
Adolf Bay
Nordenskiöld Glacier
Napier
Bruce City
Campbell Range
Watson Dale
t. Tyrrell
Tjosaas
BJÖNA HAVEN
Scale 1: 75,000
Sindballe Range
Temple Range
Hut
Bjöna Haven
TEMPLEFJORD
Cape Bjöna
Map C
78°30'
er Range
Gips Valley
Mt. Aitken
Von Post Glacier
Sindballe Ra
TEMPLEFJORD
Temple Ra.
Bjöna Haven
C. Schoultz
C. Bjöna
Colorado Hills
RD
Bruce hut
Phantom Point
The sequence of the raised and tilted shorelines
A-E I-II 1-7 a-g
Drainage slopes with mud polygons
Published by the Royal Geographical Society


USHER RANGE
River Gip
GIPS VALLEY
Scale 1:75,000
Yards
1000 0 1000 2000
Fan
Wave-cut notches
Lake Lillian
Mount Aitken
Adolf Bay
Cape Napier
Bruce City
Fan
Solifluction Slopes
BAY
Glacier
Mud polygons
Cape Scott
Solifluction slopes with polygons
Striated rock exposure on shore
CAMPBELL RANGE
N
Cape Ekholm
Whale rib
Fan
The Iron Gorge
Whale vertebra
Watson Dale
Mount Tyrrell
Eastern shores of
BILLEFJORD
Scale 1:75,000
Yards
1000 0 1000 2000
Limestone at base of cliff
Terraced fan
Limestone cliff
Phantom Point
Fan
Drainage slopes with mud polygons
Map A
The tilted shorelines of eastern Billefjord
feet
C. Napier
Phantom Pt.
300
200
100
0
Shoreline
A
B
C
D
E
F
1 2 3 4 5 6 7 8 9 10 11 12 13
Lines of levels (Map A)
0 1 mile
Vert. scale exaggerated 20 times

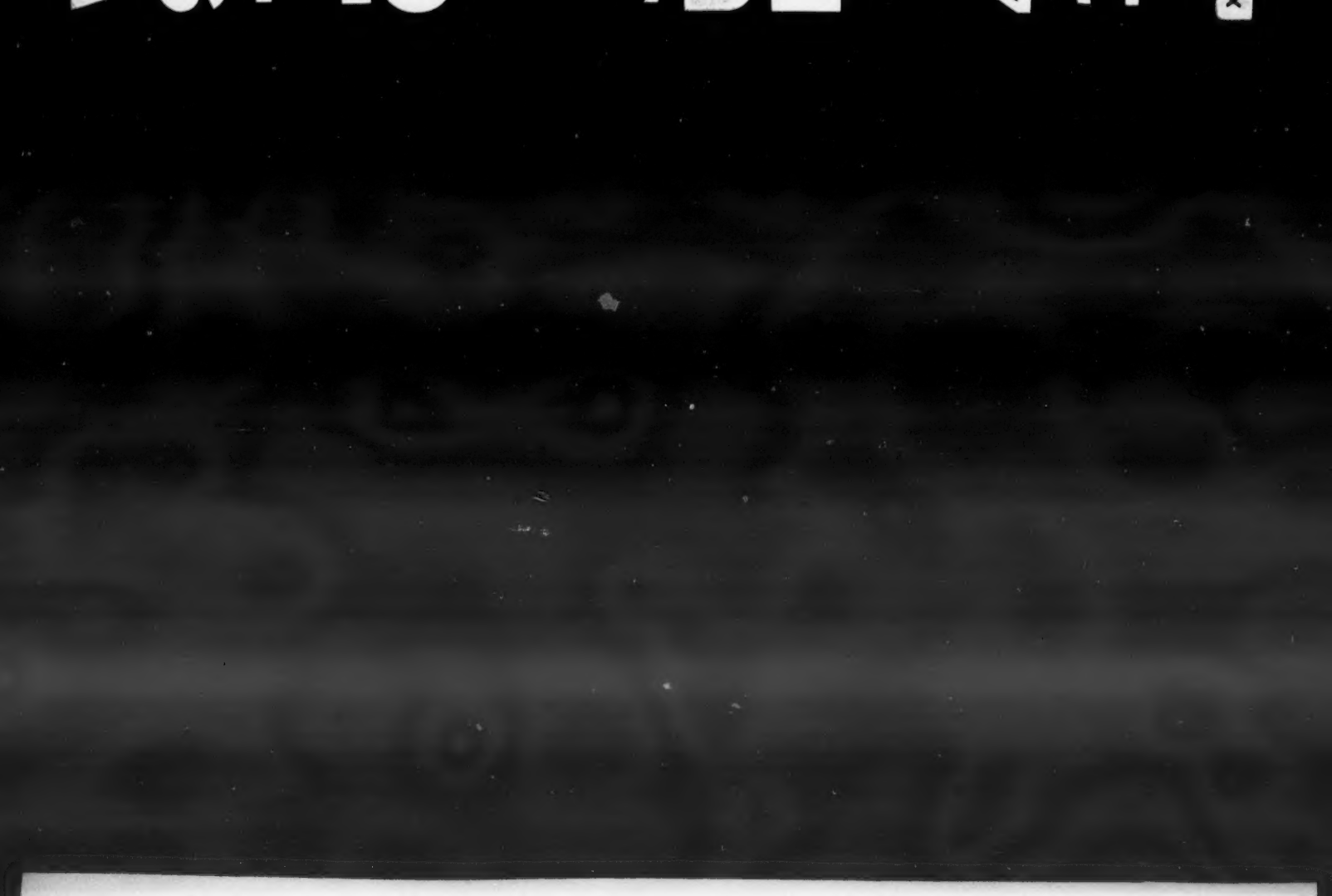



Fig. 2